A CAHNERS PUBLICATION INTERNATIONAL EDITION APRIL 17, 1986

EDN

Fast MOS static RAMs rival ECL devices' access times

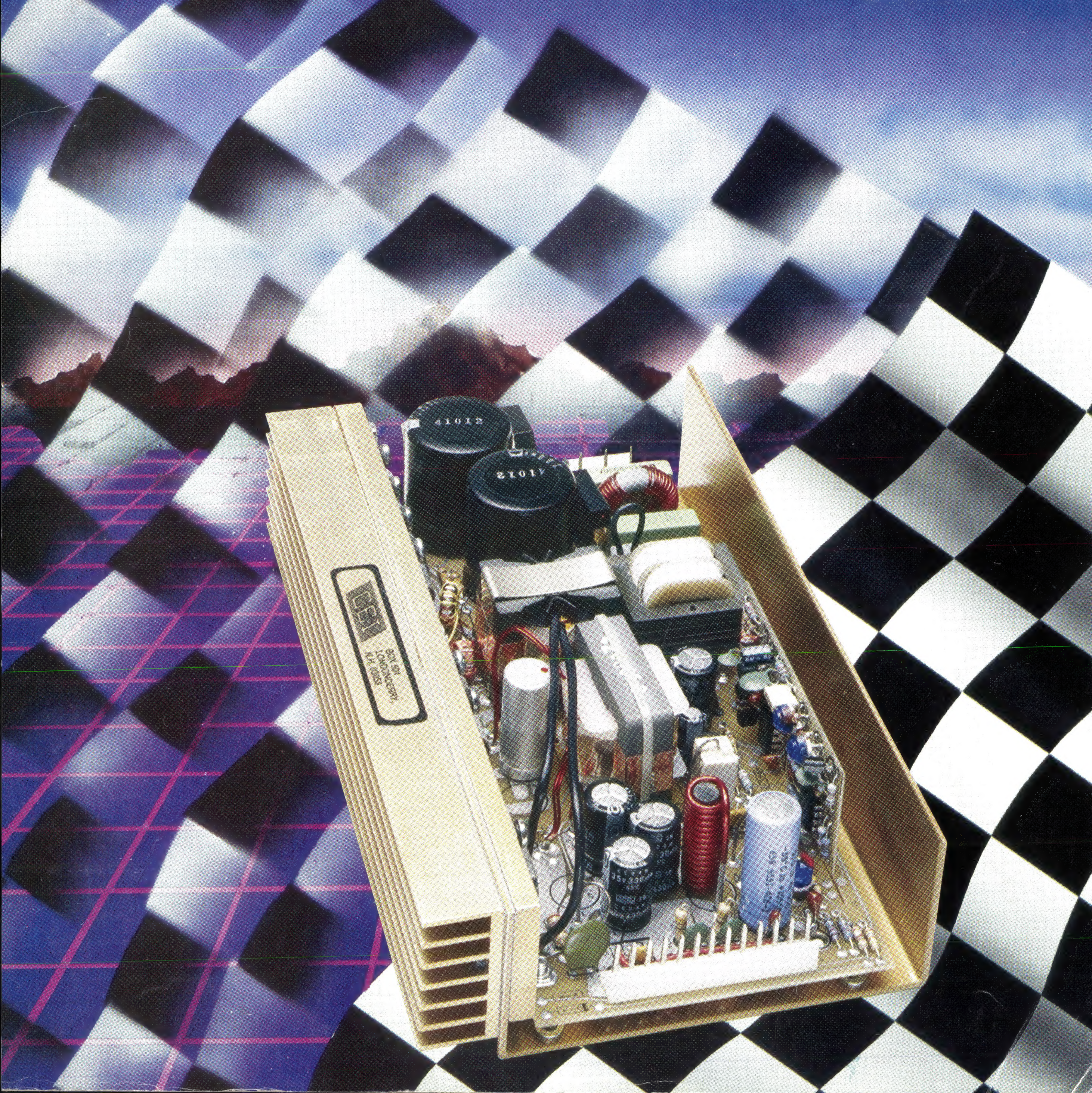
Programming aids simplify code design and modification

Digitizing-tablet resolution extends beyond 1000 lpi

Electro preview

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

High-frequency switching circu winning power-suppl



stands alone.

error correction technique, the ICL7134 provides up to 14 bits of accuracy and ultra-high stability over the entire operating temperature range. Plus the same cool low-power CMOS performance.

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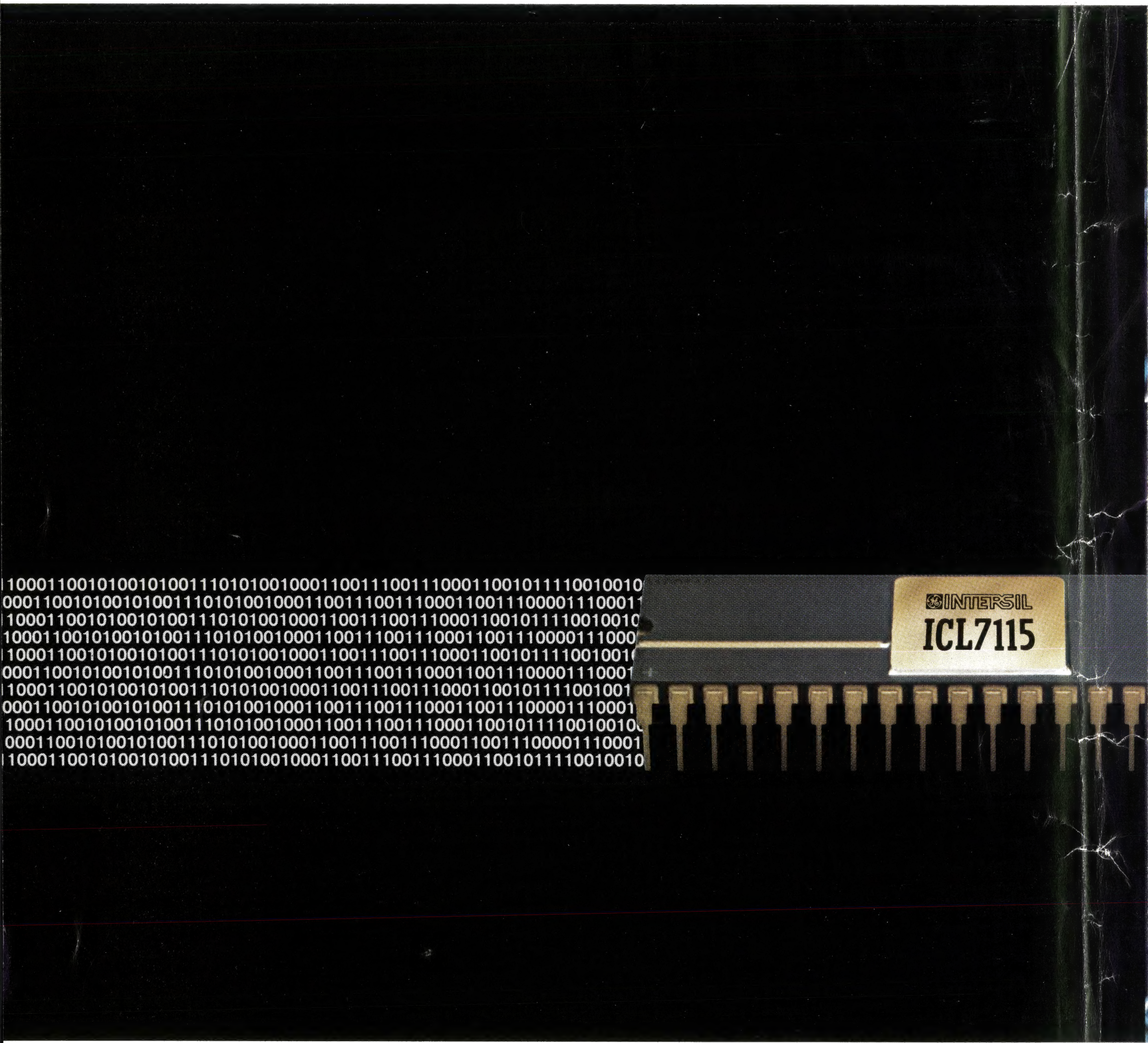
Our ICL7115



The only 14-bit monolithic A/D converter on the market today—that's Intersil's ICL7115. It's the chip that will change the definition of signal processing.

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CIRCLE NO 216

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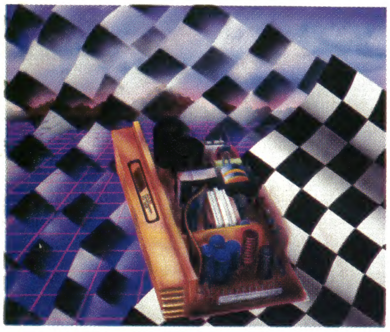
Volume 31, Number 8

EDN

April 17, 1986

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



***On the cover:** You can stay out in front of the competition by designing high-frequency off-line switching power supplies into your products. Such supplies, which operate at frequencies greater than 50 kHz, are achieving high power densities while offering such features as inrush limiting, line filtering, and remote sensing. See pg 130. (Photo courtesy CEI Corp)*

DESIGN FEATURES

Special Report: High-frequency off-line switching power supplies **130**

Today's faster switching circuitry allows manufacturers to build smaller off-line switching power supplies. The smaller the supply, however, the greater its potential for internal heating and safety problems. Manufacturers avoid these potential problems by employing innovative thermal designs and packaging methods.—*Chris Everett, Western Editor*

Feed analog signals to IBM PC-compatible personal computers **153**

A personal-computer-based data-acquisition system converts analog signals from low-level sensors—first, to a level an analog-I/O system can use, and second, to the digital ones and zeros the computer can use. Some guidelines can help you implement hardware and software solutions to the sometimes thorny interface problem.—*J Croteau, D Grant, and S Wurcer, Analog Devices Inc*

PC-based programs aid analog-circuit design and analysis **175**

You can use analog-circuit simulation software that runs on the IBM PC and compatible computers to analyze circuit designs. The programs, which augment (rather than replace) your circuit-design knowledge, let you analyze a circuit's ac and dc performance and conduct transient, Fourier, and Monte Carlo analyses.—*Richard E Kiefer, Consultant*

EPLD macrocells and feedback signals ease circuit design **200**

The AND arrays, programmable macrocells, and feedback paths of an erasable programmable-logic device augment your ability to design general-purpose logic circuits. Designs based on the device can perform their functions with fewer components than corresponding discrete-IC implementations.—*Don Faria, Altera Corp*

Designer's Guide to: Linear control-system theory—Part 2 **219**

Advanced dynamic signal analyzers (DSAs) give designers a choice of techniques for measuring a system's open-loop frequency response. This article considers the effect of DSAs on the graphical measurement techniques of linear control-system theory.—*Steve Asbjornsen and Owen Brown, Hewlett-Packard Co*

Continued on page 7

EDN (ISSN 0012-7515) is published 45 times a year, biweekly with one additional issue in January, February, March, August, and December, two additional issues in April, June, July, September, and November, and three additional issues in May and October by The Cahners Magazine Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158. William M Platt, President; Terrence M McDermott, Executive Vice President. Norman L Cahners, Honorary Chairman; Saul Goldweitz, Chairman; Ronald G Segel, President; Robert L Krakoff, Executive Vice President. Circulation records maintained at Cahners Publishing Co, 270 St Paul St, Denver, CO 80206. Second class postage paid at Denver, CO 80202 and additional mailing offices. Postmaster: Send address changes to EDN, 270 St Paul St, Denver, CO 80206.

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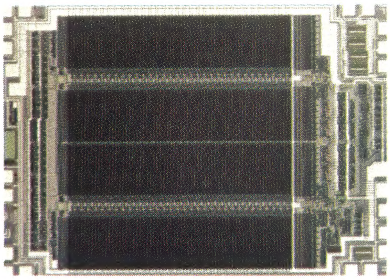
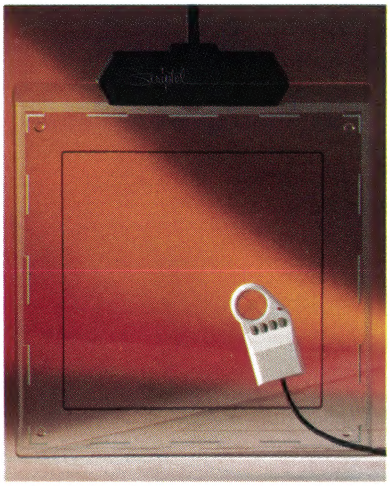


You can now employ MOS static RAMs in applications once served only by 1k- or 4k-bit ECL memories. The 16k- and 64k-bit MOS devices are achieving access times as low as 25 to 35 nsec (pg 57).



Resolution, accuracy, and hardware and software compatibility are key specs to consider when choosing digitizing tablets (pg 69).

TECHNOLOGY UPDATE

Process improvements and special features reduce high-end static-RAM access times 57

Today's fast 16k- and 64k-bit MOS static RAMs have seen their access times fall to the 25- to 35-nsec range, approaching the speeds of ECL static RAMs.—*Maury Wright, Western Editor*

Digitizing tablets offer choices of formats, operating modes, and pointers 69

Whether you're digitizing schematic diagrams or a 3-dimensional shape, you can choose from a variety of digitizing tablets, pointing devices, and output formats.—*Jon Titus, Senior Editor*

Programming aids minimize errors during software design, coding, and modification 79

By employing one or more programming aids, you can make your computer handle much of the tedious work associated with program or software-system design.—*Chris Terry, Associate Editor*

Varied Electro/86 program will emphasize IC- and system-design topics 97

The conference will include talks on the latest developments in semicustom ICs, ASICs, logic arrays, VLSI circuits, and other subjects.
—*Joanne Clay, Staff Editor*

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April 17, 1986

EDITORIAL 51

You're likely to be unsettled, as we are, to note the harmful methods a few ads still employ to get a reader's attention. The arguments frequently used to justify such ads all have serious flaws.

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INMOS introduces the transputer family. A range of evaluation boards for the first transputers is available now.

The transputer is a fast, easy to use VLSI component designed for applications ranging from single microprocessor systems to supercomputers.

The IMS T414 is the first transputer, integrating a 32 bit microprocessor, four inter-transputer communication links, 2 Kbytes of RAM, a 32 bit memory interface and a memory controller onto a CMOS chip.

The microprocessor runs at 10 MIPS and is designed specifically for the execution of high level languages. It combines direct support for multi-tasking, floating point, block transfer and record handling with sub-microsecond procedure call and task switching.

Each transputer link provides a full duplex, 10 Mbits/sec, point to point connection with an on chip DMA controller. Links are used for inter-transputer communication or, via an INMOS Link Adaptor, interfacing to industry standard byte wide peripherals.

The memory interface provides access to a linear 4 Gbyte address space at a data transfer rate of up to 25 Mbytes/sec.

Transputers are designed for ease of engineering. All transputer family devices operate from a single 5 MHz clock input, which is used to derive high speed internal clocks for all on chip systems.

When transputers are directly connected via links, additional components are not necessary. Independent or common clocking can be used, regardless of timing skew.

The configurable memory controller also requires no external components. It provides all the necessary timing and refresh signals for memory systems, comprising any mix of ROM, SRAM, DRAM and memory mapped peripherals.

Transputers are designed for ease of programming. INMOS offers development systems which provide integrated editing, compiling and source level debugging for both single and multiple transputer applications, using C, Pascal, Fortran and occam.

In applications requiring only a single computing element, the transputer's speed, minimal support component requirements and programming efficiency provide significant cost/performance advantages over conventional microprocessors.

Systems of any size can be built from interconnected transputers, using the links. The same program can be configured to run on one, tens or thousands of transputers allowing a simple trade off between performance and cost.

The transputer family already includes 32 bit and 16 bit transputers, peripheral controllers, evaluation boards and development tools. Start assessing its capability for yourself now with an IMS T414 evaluation board.

TRANSPUTER PRODUCTS	
IMS T414	**32 Bit, 2 Kbyte RAM, 4 Transputer links**
IMS T212	**16 Bit, 2 Kbyte RAM, 4 Transputer links**
IMS C001	Transputer Link Adaptor, Separate 8-Bit input and output
IMS C002	Transputer Link Adaptor, Multiplexed 8-Bit input/output

DEVELOPMENT TOOLS	
IMS D100	INMOS Transputer Development System
IMS D600	Transputer Development Software, VAX-VMS
IMS D700	Transputer Development Software, IBM-PC

EVALUATION BOARDS	
IMS B001	Double Eurocard, IMS T414, 64 Kbyte RAM, 2 x RS232C ports
IMS B002	Double Eurocard, IMS T414, 2 Mbyte RAM, 2 x RS232C ports
IMS B004	IBM-PC add on card, IMS T414, 1 Mbyte RAM

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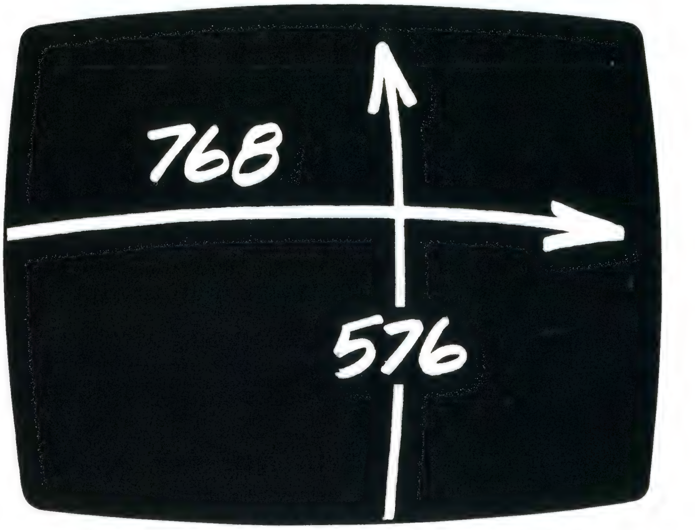
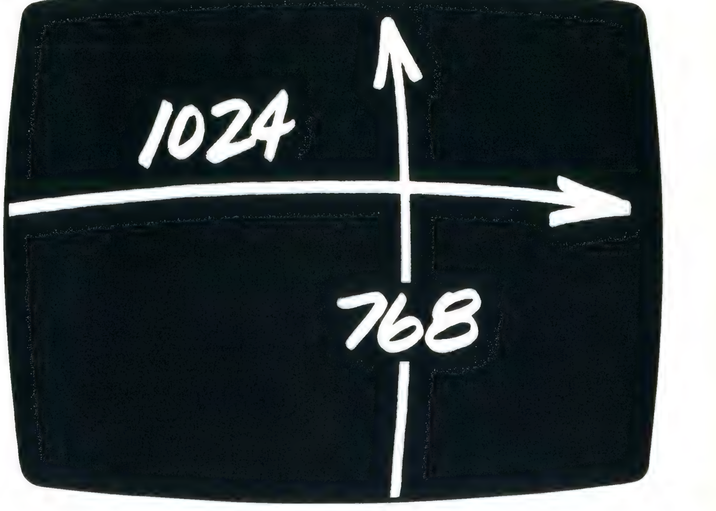


PERSONAL COMPUTER GRAPHICS



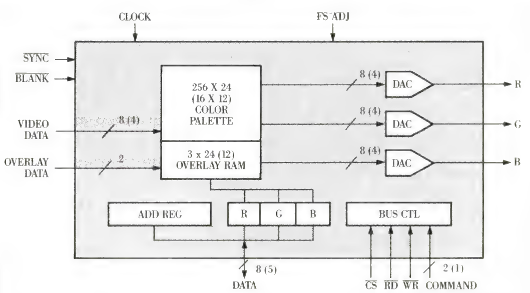
2-D ENGINEERING WORKSTATIONS

Our new family of RAMDACs is bound to make a Brooktree convert out of you.

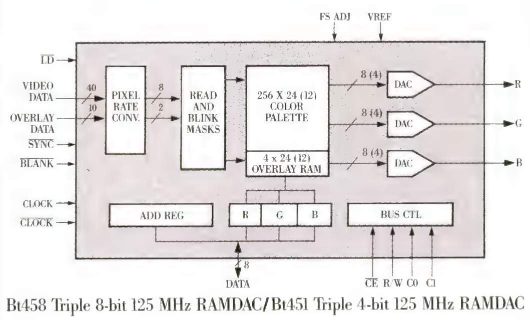
Who gives a duck's tail about RAMDACs, anyway?

Apparently, none of our competitors. None has chosen to produce more than one RAMDAC. None, we believe, has taken the time or effort to design even *one* RAMDAC the right way. The Brooktree Way.

We, on the other hand are now introducing four new RAMDACs—high performance D-to-A circuits with built-in color palettes. They make it easier than ever for you to achieve your new year's resolutions, no matter what type of graphics system you're designing. And they all take advantage of our revolutionary low-glitch architecture.



Bt453 Triple 8-bit 40 MHz RAMDAC/Bt450 Triple 4-bit 70 MHz RAMDAC



Bt458 Triple 8-bit 125 MHz RAMDAC/Bt451 Triple 4-bit 125 MHz RAMDAC

Ask about our Sidecar RAM.™

Here's a vivid example of our commitment to elegant design: Each of our four new RAMDACs includes two overlay ports that address a separate color palette. This makes cursors, menus, alphanumeric overlays, etc. easier to handle.

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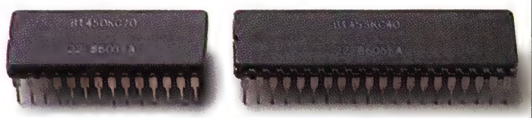
Ask about our Triple 4-bit RAMDAC.

Our Bt450 is a 70 MHz, 16-color palette, Triple 4-bit



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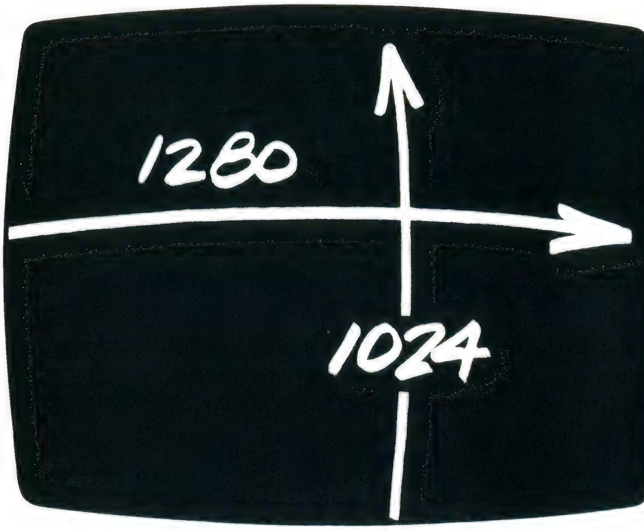
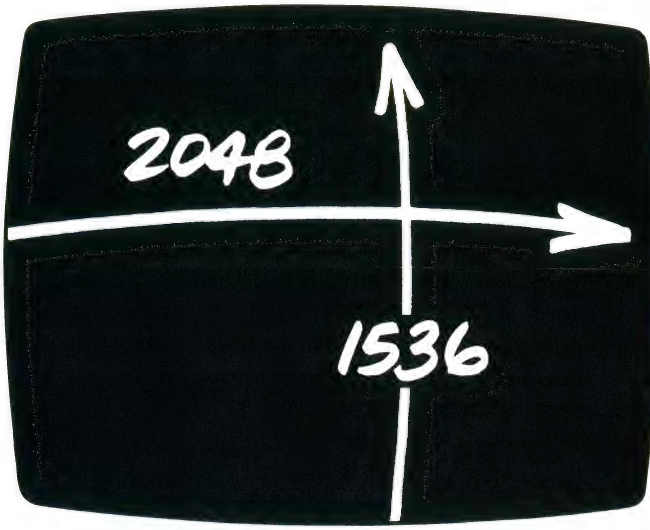
resolutionary RAMDACs.



HIGH RESOLUTION ENGINEERING WORKSTATIONS



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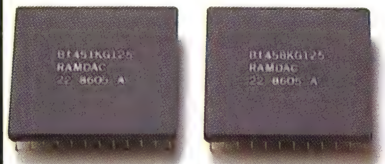
Ask about our Triple 8-bit RAMDAC.
Our Bt453 is a 40 MHz, 256-color palette, Triple 8-bit RAMDAC—also in a single monolithic CMOS chip.

Frankly, it's not even fair to compare it to the IMSG170. It's six bits. Ours is eight.

So only Brooktree can give you, simultaneously, 256 colors out of a 16.8 million-color palette. That means you can do solids modeling without color compromise.

Who can you ask about our 125 MHz RAMDACs?
It's tough not having direct competition. Nobody to blow out of the water.

Our Bt451 is a 125 MHz 256-color palette, Triple 4-bit RAMDAC. The Bt458 is a pin-compatible 8-bit version. Also 125 MHz. Both TTL-compatible. *Not* ECL.



And because they're pin compatible, you can design one system that can be switched from 4-bit to 8-bit DAC resolution by exchanging just one chip.

Just look at these features: On-chip 4:1 and 5:1 Pixel Rate Converter, direct interface to frame buffer RAM, separate MPU interface, blink/blank registers and fully dual-ported RAM cells.

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The PAL 24B Series.

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NEWS BREAKS

EDITED BY JOAN MORROW

RAD-HARD 16k-BIT STATIC RAM MADE WITH CMOS PROCESS

Boasting the greatest radiation hardness of any commercial CMOS memory, the HS-65262RH (16k-bit) static RAM from Harris Corp (Melbourne, FL, (305) 724-7800) resists latch-up from transient ambient radiation in excess of 2×10^{12} rads(Si)/sec. It withstands a total radiation dose of at least 200,000 rads(Si). Functionally compatible with Sandia's SA-3240 and Harris's HM-65262, the HS-65262RH delivers typical access times of 100 nsec over −55 to +125°C and operates asynchronously at supply currents of only 6 mA/MHz max from a 5V source. In its low-power standby mode, the part draws less than 200 μA. Samples of the device are supplied in a 20-pin cerdip for $1000 (100) for the Class-B version or $1395 (100) for the Class-S version.—Denny Cormier

DUAL-PORT VIDEO-MEMORY TESTER TESTS AT 50 MHz

The J937 Memory Test System from Teradyne (Canoga Park, CA) can test video RAMs at a system frequency of 50 MHz unrestricted and 100 MHz double-clocked. It has an accuracy of better than 1 nsec and capacitive loading of 30 pF. Because the system can test all parameters to spec, you can also use it for parts characterization and evaluation. Prices start at $350,000.—Margery S Conner

MOTOROLA EXPECTS TO ENTER DSP MARKET IN THE THIRD QUARTER

Motorola's Microprocessor Products Group (Austin, TX, (512) 440-2039) expects to join the growing ranks of DSP-chip suppliers in the third quarter. The company's first dedicated DSP product, the DSP56200, will provide either a dual- or single-channel finite-impulse-response (FIR) filter. When operating in its dual-channel mode, the chip will let you select as many as 128 taps per filter section. In the single-channel mode, as many as 256 taps will be available. Unused filter taps will provide general-purpose data storage in addition to the chip's 512 internal RAM locations for temporary data and filter coefficients. The manufacturer projects a price of less than $25 per chip (1000).—Jon Titus

SEEQ UNVEILS INDUSTRY'S FIRST CMOS 256k-BIT EEPROM

Last month, Seeq Technology (San Jose, CA, (408) 942-1990) introduced the 28C256, the first 256k-bit (32k-byte) EEPROM made in CMOS. By applying its low-power CMOS 1.25-μm fabrication technology, Seeq has kept the part's active supply current to 60 mA from one 5V source; in standby mode, the 28C256 draws only 100 μA. The company's high-endurance Q-cell design allows the 28C256 to support as many as 1,000,000 write/erase cycles with an average write time of 160 μsec per byte during the part's 64-byte page-write mode; maximum read access time is 250 nsec. Other features include bulk chip erase, an on-chip timer, data polling, and power-up/-down protection. The 28C256 sells for $195 (100).—Denny Cormier

CMOS CHIPS SHRINK PC/AT SINGLE-BOARD COMPUTER SIZE

Two CPU/peripheral controller ICs used in Faraday Electronics' (Sunnyvale, CA) single-board computer line are offered for OEMs building PC and PC/AT bus-based systems. The FE3000 is compatible with Intel's 16-bit 80286 and is upward compatible with the 80386. The chip integrates 53 components and shrinks board size by 62%. It supports 6-, 8-, and 10-MHz clock speeds with zero wait states and can accommodate 256k- and 1M-bit dynamic RAMs. The chip incorporates nonmaskable-interrupt and DMA refresh-control logic, an 82288-compatible bus controller, and an 8284/82284-compatible clock generator.

Faraday also offers the FE2010, capable of reducing an 8088-based PC mother board by 77%. Both devices work in conjunction with the company's PROM-based BIOS. The chips come in 84-pin J-leaded surface-mount plastic chip carriers. The FE2010 is priced at $76, and the FE3000 sells for $45 (100).—Margery S Conner

TWO COMPANIES INTRODUCE HIGH-SPEED CMOS GLUE LOGIC

Despite the general slowdown in the TTL glue-logic market last year, two companies have introduced high-speed (greater than 50 MHz) CMOS versions of the widely used 54/74 Series logic devices. Parts from both companies satisfy MIL-STD-883.

Using its 1.2-μm CEMOS process, Integrated Device Technology (Santa Clara, CA, (408) 727-6116) has started its 39C800 glue-logic line with three 9-bit noninverting devices: the IDT-39C823 bus interface register, the -39C843 bus interface latch, and the 39C863 bus transceiver. All three IDT parts cost $5.90 (100).

VTC Inc (Bloomington, MN, (800) 882-2667), which released the first 20 of its 50 high-speed 1.6-μm CMOS V54/74 ACT glue-logic devices late last year, including 8-, 9-, and 10-bit buffers, latches, flip-flops, and transceivers in 20- and 24-pin DIPs, is now offering all 50 parts in sample quantities for $3.25 (100). In addition to improved noise margins over conventional TTL glue-logic devices, inputs to VTC's ACT parts can withstand 2000V of ESD.—Denny Cormier

CHIP MULTIPLIES TWO 16-BIT INTEGERS IN 5 nSEC

Having a typical 5-nsec multiply time, the B3018 chip from Bipolar Integrated Technology Inc (Beaverton, OR, (503) 629-5490) operates on 16-bit words. An external connection lets you select a signed or an unsigned format for either integer or fractional values. The chip provides its 32-bit result in parallel; however, internal control circuits let you access the most-significant and least-significant words individually. You can force the chip to round or adjust the format of the multiplier's result. The chip's overflow, zero-status, and negative-sign flags are held in an internal status latch and are available separately on three output pins. The manufacturer expects to offer samples of the multiplier in a 108-pin PGA package in June for $200 and $300 per chip.—Jon Titus

FERROELECTRIC MEMORY CELLS PROMISE FAST, NONVOLATILE RAMs

Ramtron (Colorado Springs, CO, (303) 594-4455) has developed a potassium-nitrate (K_2NO_3) thin-film cell. The company is sampling a 1k-bit, undecoded, nonvolatile memory array with 15-μm-square bit cells, which furnish access times of less than 20 nsec. The company has tested cells as small as 2-μm square and claims access time is a function of feature size and that subnanosecond access times are feasible with conventional lithographic techniques. Each memory cell is composed solely of a capacitor, formed by metallizing plates on the top and bottom surfaces of a thin film of potassium nitrate. When the film is heated to approximately 125°C, the potassium-nitrate molecules become electrical dipoles and exhibit ferroelectric properties that remain after the film is cooled.

An electric field applied to the thin-film capacitor orients the dipole up or down depending on the applied field polarity, which varies the cell capacitance. At a 2000 Å film thickness, less than 4V generates a field strength adequate to flip the dipole orientation, making the device compatible with integrated circuitry. Once oriented, the dipole maintains polarity even in the absence of an electric field, resulting in nonvolatility. The company plans to offer fully operational, high-speed, nonvolatile RAMs by the end of this year. —Steven H Leibson

NEWS BREAKS: INTERNATIONAL

BY PETER HAROLD

LOGIC ANALYZER SUITS INVESTIGATION OF 32-BIT SYSTEMS

The PM3570 modular logic analyzer from Philips (Eindhoven, The Netherlands, TLX 51573) provides you with as many as 83 state-analysis channels and operates at clock speeds as high as 20 MHz. It has a 32-channel 100-MHz transitional timing analyzer, which you can reconfigure to provide several channel-number/frequency combinations, including 8-channel/400-MHz and 16-channel/200-MHz operation. Alternatively, you can use the timing section to implement an additional 32 state-analysis channels, to provide a total of as many as 115 state channels. The state and timing sections have cross-trigger/arm and time-correlated capabilities, with simultaneous display of state and timing information. Both the PM3570 and the entry-level PM3565, which can be fully upgraded to the PM3570 specification, feature software performance analysis and are priced from approximately HFl 25,000.

PC-BOARD CAD SOFTWARE HANDLES 16-LAYER BOARDS

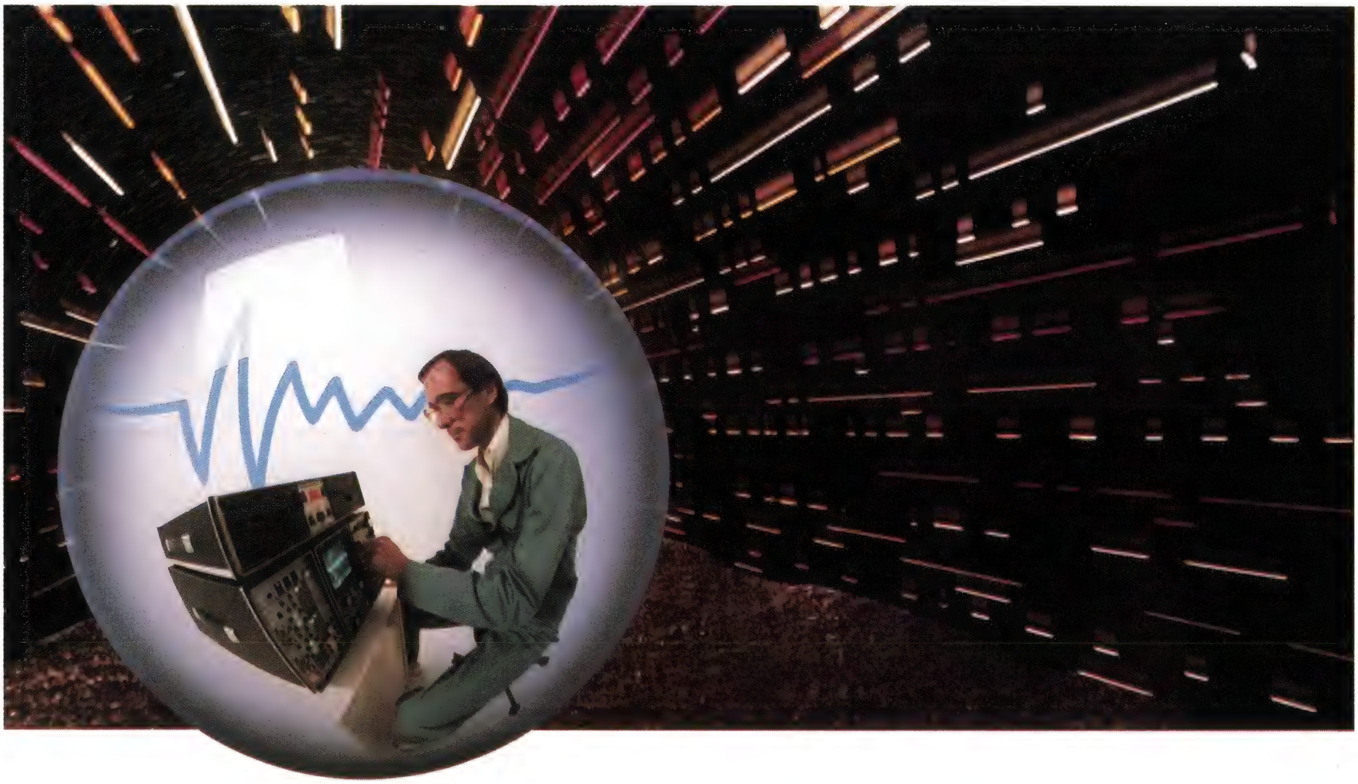
Priced from £8000 and £12,000, the Ranger pc-board CAD software from Seetrax (Hayling Island, UK, TLX 86572) provides interactive or fully automatic component placement and routing of pc-board designs on IBM PC/AT, Olivetti M24-SP, or compatible computers. The system handles board sizes as high as 32.76 in. square with a working resolution of 0.001 in. You can design with as many as 16 track layers and 16 different track widths. Post-routing design-rule checks include automatic checking of track width, pad size, clearance, and connectivity. With a mouse, you can enter circuit data either as a schematic diagram or as a net list. In addition to generating the pc-board and solder-resist art, the CAD software produces circuit schematics, assembly drawings, parts lists, and NC-drill tapes.

FREQUENCY INVERSION IC SCRAMBLES VOICE-BAND COMMUNICATIONS

The FX204 variable split-band frequency inversion IC from Consumer Microcircuits Ltd (Witham, UK, TLX 99382) allows you to scramble speech transmissions, making them unintelligible to unauthorized listeners. Operating over a 3400-Hz bandwidth, the IC uses switched-capacitor filters to split the voice band into high- and low-frequency bands; balanced modulators invert each frequency band around its own center frequency. You can externally program the split point to 32 different frequencies, suiting the device to fixed programmable or rolling-code speech scramblers. The IC can handle the input or output of synchronization tones if necessary. Fabricated in 5V CMOS, which suits it for use in battery-powered communications equipment, the IC comes in a 24-pin DIP or surface-mount package and sells for £8 to £9 (1000).

MAJOR VME BUS MANUFACTURERS ENDORSE VSB-BUS

Philips (Eindhoven, The Netherlands), Plessey Microsystems (Towcester, UK), Thomson Semiconductors (Paris, France), and the originator of the VME Bus, Motorola (Phoenix, AZ), have jointly announced their commitment to support VSB (VME Subsystem Bus) as the preferred local extension bus for VME Bus systems. Developed by a working group of the IEC in conjunction with these companies and VITA (the VME Bus International Trade Association), the VSB is an amalgamation of the best features of the VMX Bus and Motorola's MVMX32 Bus, which it developed to support the 68020 μP.



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2000-2500 MHz	2.7 dB max.
ISOLATION	
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500-1000 MHz	30 dB min.
1000-2000 MHz	25 dB min.
2000-2500 MHz	20 dB min.
SWR	1.5 max. ("on" state)
SWITCHING SPEED	1 μsec. (max.)
MAXIMUM RF INPUT	+20 dBm
CONTROL	+5 V (5 mA max.)
OPERATING TEMPERATURE	−54°C to +100°C
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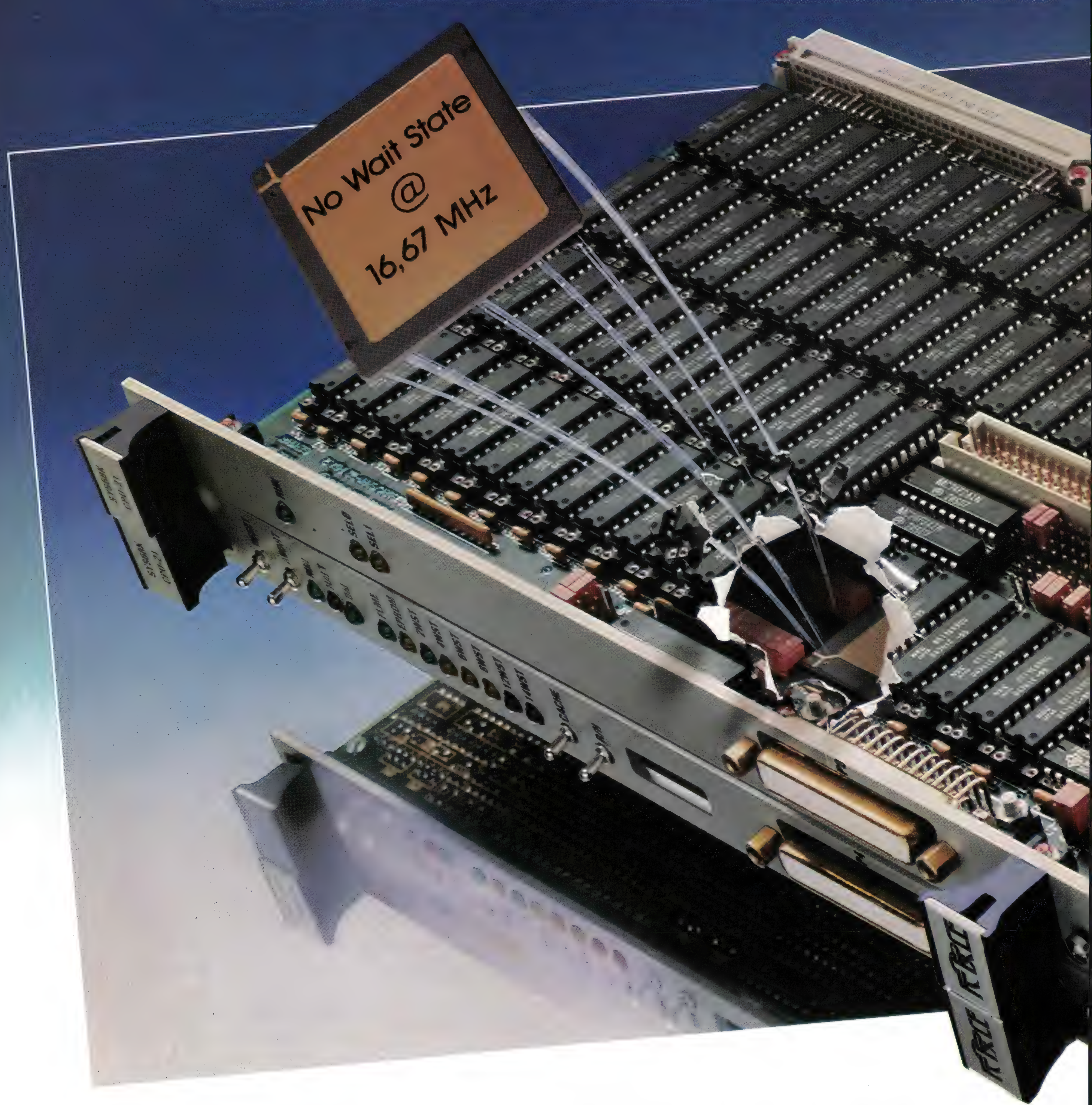

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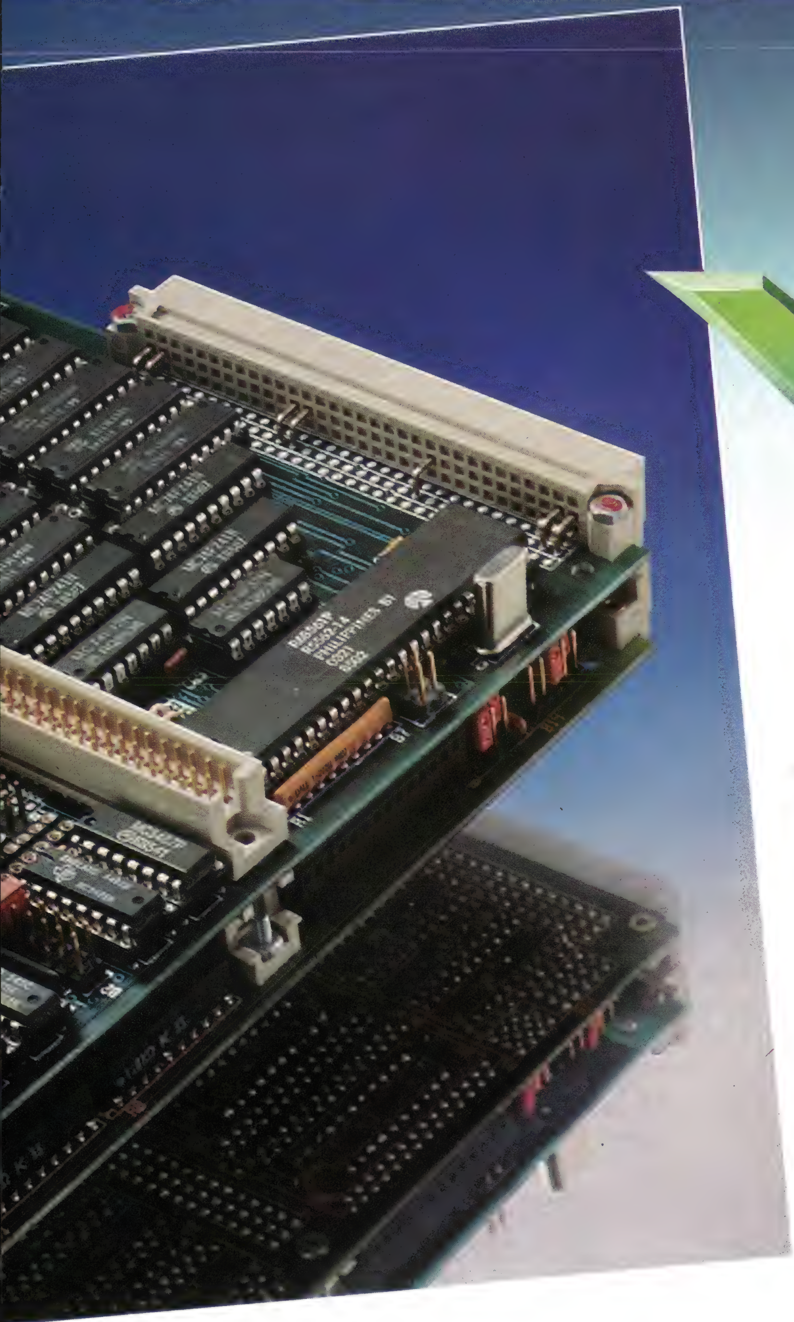

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CIRCLE NO 110

SIGNALS & NOISE

US IC manufacturers ignore the ZIP at their peril

Dear Editor:

As a component engineer, I've seen US manufacturers of ICs make some costly mistakes in packaging. Over the last several years, the most common mistake they've made is to put memories in unnecessarily long DIPs—DIPs too long to allow engineers to fit everything they needed to on a pc board. Instead of a 0.045-in. maximum overhang from the centerline of the end pins to the edge of the package (half-lead style), which would allow for maximum packing of memory arrays, manufacturers used a package with an overhang of 0.050 in. or more. We found the memories we needed in short packages, though—in Japan.

It looks as if we're ready to hand Japan another victory. Many US manufacturers (especially the largest) are refusing our requests for a new package, while the Japanese are responding positively.

High-performance applications, such as ours at Intergraph, are often the proving ground for the latest ICs and, periodically, the latest packages. PGAs and SMDs have been discussed a lot lately, but a new package is poised to steal many of the SMD's applications. The ZIP (zigzag in-line package) offers greater density and is less expensive and easier to implement than are SMDs.

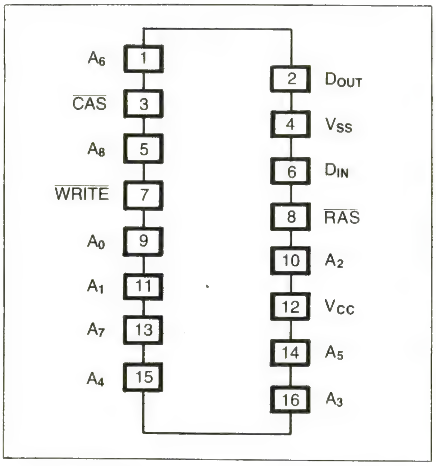
PC-board area is usually at a premium in high-performance applications. Although SMDs use considerably less space than do DIPs, ZIPs use even less space. An added bonus for pc-board designers is the easy straight-line routing of ZIP memory arrays.

Further, ZIPs use traditional soldering equipment and existing or modified SIP-insertion equipment. In contrast, SMDs require new equipment for both operations.

The only drawback ZIPs appear to have is that their pin count will probably peak at 24 or 28 pins, which isn't really much of a limitation. High-performance dynamic RAMs, static RAMs, PROMs, PLDs, and glue parts, consisting mostly of 8-, 9-, or 10-bit-wide parts for bus applications, will fit easily in a 16- to 28-pin ZIP. (See the accompanying illustration, which depicts a ZIP for a 256k-bit dymanic RAM.)

The ZIP package is a definite winner in high-performance applications. US IC manufacturers had better wake up to that fact before they lose another proving ground and the revenue that goes with it.

Sincerely yours,
M Tony Young
Huntsville, AL



Engineers need clerical help

Dear Editor:

I enjoyed your editorial "Cut out the paperwork" (EDN, October 31, 1985, pg 45). The problem is all too true. I have been an engineer in industry for 36 years, and during that time I have repeatedly been amazed and disheartened by the amount of clerical work and unnecessary paperwork required of us engineers.

Today, for example, I spent 15 minutes at the copy machine, 20 minutes running my own prints, 30 minutes filing new changes in specification books, 20 minutes trying to find a catalog in the library file, 10 minutes filling out company forms, etc.

Continued on pg 34

TEK'S COST-EFFECTIVE, 32-BIT ANSWER FOR INDEPENDENT THINKERS.

For less than $10,000, you can add the Tek 6130 and turn your 4100 color graphics terminal into a 32-bit workstation. It's a combination that lets you configure a higher-performance, stand-alone system in RS-232 environments. Standard features of the 6130 include the UTek operating system—an extremely powerful yet friendly version of Unix—as well as 20 MB hard disk; 360 KB integrated flexible disk; 1 MB of parity RAM; Local Area Network (LAN) port; and GPIB port.

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The optional Casual User Interface (CUI), a highly interactive menu-based program, enables you to perform basic system activities without detailed knowledge of the Unix command syntax.

Five fully integrated application systems are now available for the 6130. These preconfigured systems offer the hardware and software you need for applications such as computer-aided-drafting, technical data analysis and presentation, and Unix software development.

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The 32-bit Tektronix 6130 supports Tek's 4100 family of desktop terminals and the 4692 high-performance color copier.

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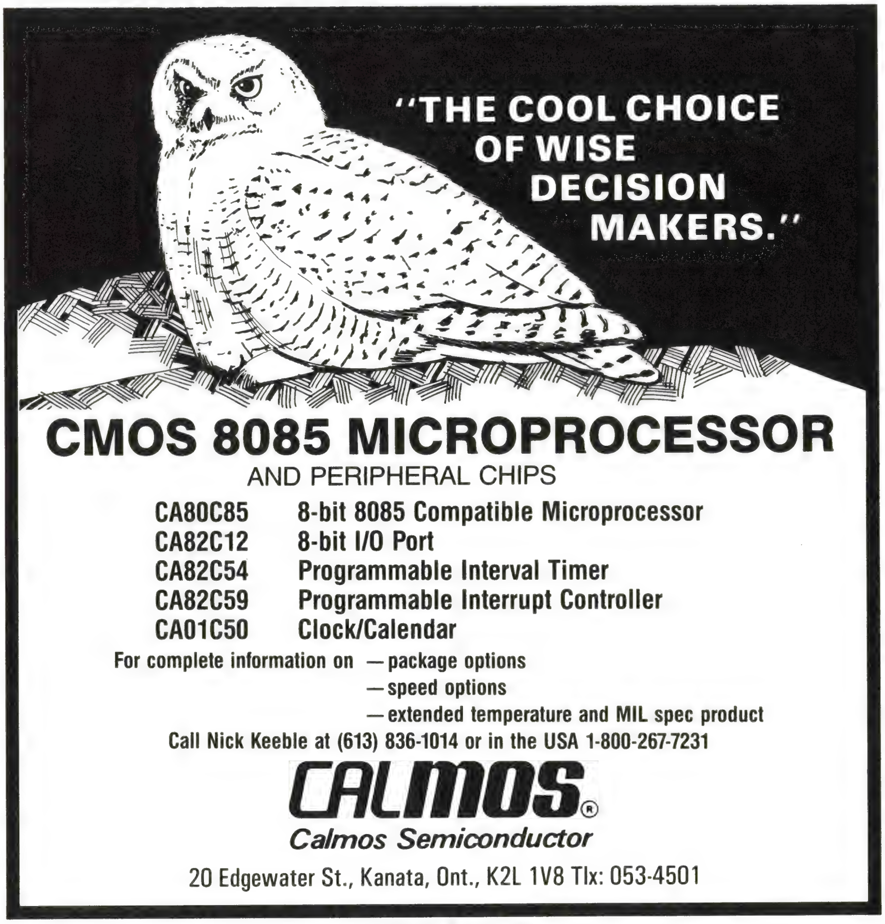

CIRCLE NO 15

SIGNALS & NOISE

I think the problem has to do with corporate cultural taboos and status symbols. It is taboo for any engineer or engineering group to be provided with administrative or clerical assistants on a full-time basis. In fact, even to ask for such a thing is likely to get you classified as someone who "doesn't work well with facilities at hand" or "isn't productive without assistance." The corporate culture—and this problem is widespread throughout engineering companies—considers the engineer a body that generates certain outputs when given certain inputs, as a computer does. Computers don't need assistants. Neither do engineers.

Status is important, and balancing status so that no one feels discriminated against is even more important. An assistant, who would be a status symbol, cannot be tolerated.

The fact remains that the productivity of most engineers could be increased by 50% by eliminating dog work and most of the paperwork. It's surprising that for so many years the US corporate culture has put a higher value on status than on productivity and profit.

You can be sure that engineers who own and run their own companies have their own secretaries and other assistants. But companies don't perceive the need for this type of help at the lower engineering levels, and that's a mistake.

Your editorial should shake up some of the people who make this mistake. Keep punching away at the subject. It's important to the nation and to us engineers who are relegated to being our own clerks and gofers.

Name withheld upon request

WRITE IN

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CIRCLE NO 112

CALENDAR

6th International Workshop on Expert Systems and their Applications, Avignon, France. Agence de l'Informatique, Tour Fiat, Cedex 16, 92084 Paris-La Defense, France. (331) 47-96-43-14. April 28 to 30.

Speech Tech '86, New York, NY. Media Dimensions, 42 E 23rd St, New York, NY 10010. (212) 533-7481. April 28 to 30.

Comdex/Spring, Atlanta, GA. Interface Group, 300 First Ave, Needham, MA 02194. (617) 449-6600. April 28 to May 1.

Dexpo South (DEC-Compatible Exposition and Conference), Dallas, TX. Expoconsul International, 3 Independence Way, Princeton, NJ 08540. (609) 987-9400. April 28 to May 1.

Technical Project Management Techniques (short course), Milwaukee, WI. Peter Tocups, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N 6th St, Milwaukee, WI 53203. (414) 224-3952. April 28 to May 1.

IEEE Applied Power Electronics Conference and Exhibit, New Orleans, LA. Melissa Widerkehr, APEC, 655 15th St NW, Suite 300, Washington, DC 20005. (202) 347-5900. April 28 to May 2.

Programming in Lisp and Prolog, Boston, MA. Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. April 29 to May 2.

Design to Test (short course), Milwaukee, WI. Peter Tocups, Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N 6th St, Milwaukee, WI 53203. (414) 224-3952. May 1 to 2.

CALENDAR

Interfacing the IBM PC with the STD Bus for Instrumentation, Data Acquisition and Control (short course), Indianapolis, IN. Pat Fox, Purdue University, School of Engineering and Technology, 799 W Michigan St, Indianapolis, IN 46202. (317) 264-2534. May 1 to 3.

36th Electronic Components Conference, Seattle, WA. Tom Pilcher, Publicity Chairman, Mallory Capacity Co, Box 372, Indianapolis, IN 46206. (317) 261-1306. May 5 to 7.

Canadian High Technology Show, Ottawa, Canada. International Marketing Services, 1030 S LaGrange Rd, LaGrange, IL 60525. (312) 354-3900. May 6 to 7.

Grounding and Shielding (short course), San Jose, CA. Interference Control Technologies, Box D, Gainesville, VA 22065. (703) 347-0030. May 6 to 9.

Programming in Lisp and Prolog, Palo Alto, CA. Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. May 6 to 9.

Programming in Lisp and Prolog, Toronto, Canada. Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. May 6 to 9.

Association for Systems Management Annual Conference, New Orleans, LA. Association for Systems Management, 24587 Bagley Rd, Cleveland, OH 44138. (216) 243-6900. May 11 to 14.

American Consulting Engineers Council (ACEC) Annual Convention, Orlando, FL. ACEC, 1015 15th St NW, Washington, DC 20005. (202) 347-7474. May 11 to 15.

Optical Storage Forum, Denver, CO. Cartlidge & Associates, 1101 S Winchester Blvd, Suite M-259, San Jose, CA 95128. (408) 554-6644. May 12 to 14.

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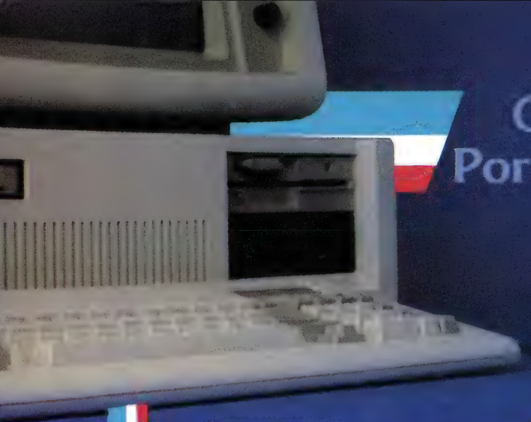

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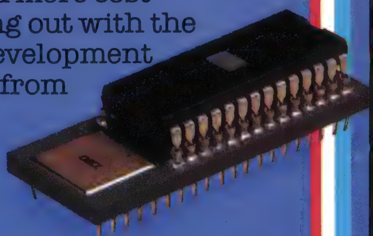

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Getting the (male) engineer's attention

You're likely to be unsettled, as we are, to note the methods a few ads (in this magazine and others in the industry) still employ to get a reader's attention. It's tempting, after an initial discomfort, to dismiss these familiar ads as harmless: "They don't show that much skin," "there are as many beefcake ads as cheescake ones," and "sex is used to sell everything" are three arguments frequently used to justify them. But these arguments have serious flaws.

All the arguments fail completely to acknowledge the harmful effect of ads that treat women as objects, regardless of what's explicitly shown. The first implies that there is such a thing as too much skin—a point that the argument's proponent undoubtedly feels uniquely qualified to determine. This argument prudishly suggests that an ad could be objectionable only because of what it explicitly might show. As such, the argument is naive: Everyone knows the subtlety of suggestion is often more powerful than the direct assault. There's something equally unsettling about an ad that, for example, depicts fully clothed women while implying that they're confined to pink-collar ghettos—classes of low-paying jobs predominantly held by women.

The second argument concedes that the ads might be degrading but contends that both sexes are treated equally. Philosophy professor Ann Garry refuted this view in her essay "Pornography and Respect for Women." She noted that "losing respect for men as a class (men with power, typically Anglo men) is more difficult than losing respect for women or ethnic minorities as a class." Moreover, ads depicting men often involve sports themes, and an athletic image commands respect in our society. In contrast, the ads featuring women concentrate on the model, or a part of the model, purely as a prop to a (male) reader's successful lifestyle.

Relative to the "sex is used to sell everything" argument, we acknowledge that people buy a plethora of products, from perfume to automobiles, that they hope will at least slightly enhance their attractiveness. We sidestep the question of whether sex should be used to sell sex appeal; we simply note that sex is inappropriate for selling single-board computers.

Rick Nelson

Rick Nelson
Managing Editor

WEEK 25

Design with our new Am29525 Dual 8-Deep Pipeline Register and your pipelined system will never work better. That's because the Am29525 is the only pipeline register that also lets you dip into the data in any order, at any time.

To start with, the Am29525 is a pipeline register that is dual 8-byte deep. Or single 16-byte deep. It's programmed to hold, shift or load data via microcode instructions. And, while the I/O is three-state TTL-compatible, the innards are straight ECL. So its access time is a swift 21ns.

Am29525

Out of order.

On the other hand, the Am29525 is also a random access register file, with all 16 internal registers instantly available. Instead of the confines of first-in, first-out rules, you can grab an arbitrary 8-bit word whenever you want. So system performance is significantly improved.

What's more it's available in space saving, .4″ wide 28-pin DIP packages.

The Am29525.

It's unlike any pipeline register you've ever used. Because it's more flexible than any pipeline register you've ever used.

Sometimes you improve things by not following orders.

CIRCLE NO 156

WEEK 26

Ask us if we second source the popular X305 microprocessor architecture and we'll answer instantly: You bet.

Am29X305A

Got a second?

Our new Am29X305A 8-Bit Microcontroller is a plug-in replacement for the 8X305 chip you're using now. The same 200ns speed. The same highly integrated design that lets you read, mask, shift, operate on, rotate, merge and store data in a single instruction. Now available from two sources, assuring you of a steady supply for all your manufacturing needs.

One more thing. The Am29X305A is fabricated using our IMOX™ process, known throughout the industry for its outstanding performance.

And that makes the Am29X305A second to none.

CIRCLE NO 195

WEEK 27

Floating point arithmetic is no longer the chore it used to be, thanks to our new Am29325 32-Bit Floating Point Processor.

Sure it's fast. A worst-case multiply takes but 150ns. But the real story is how easy it is to use. The Am29325 is a single-chip, non-pipelined, drop-in part—a true, easy-to-interface, black box solution.

Am29325

It's simple arithmetic.

Forget about internal pipeline registers, latency delay times, exotic software routines. Instead, start developing more powerful and more accurate array processors, desk top computers, digital signal processors and sophisticated robots that take less time to design and even less time to debug.

The Am29325. One easy-to-use chip that adds up to higher performance.

Could arithmetic be any simpler?

CIRCLE NO 119

WEEK 28

Every new IC claims reduced boardspace. But this baby delivers. The Am29C101 is a CMOS 16-Bit Slice, and the newest member of our 2900 family gone CMOS. It is equivalent to four 2901s. Plus one 2902.

The pin count went from 172 to 64. And package count from 5 to 1.

Power's part of the reducing program. You'll need only 0.7W. (Equivalent bipolar parts typically require 5.8W.)

Am29C101

Lose ugly fat. Fast.

How much performance did we have to sacrifice? None. The speed of the Am29C101 is equivalent to 2901C-based systems.

The Am29C101 is software compatible, so the only thing you'll need to modify is your PC board layout.

It's expandable for longer word lengths (16-, 32-, 48-bit systems, etc.). And it's available in 64-pin plastic or ceramic DIP, 68-pin PLCC, or ceramic LCC.

Ask for the Am29C101 and cut the fat out of your next system.

CIRCLE NO 234

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So where's seeking the impossible gotten us? Right where we expected. After twenty-six weeks, we're 26 for 26. Batting a cool 1,000. And here's what the world is telling us:

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INT-STD-500

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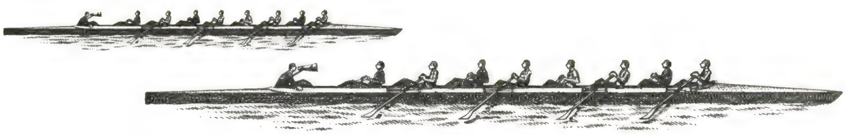

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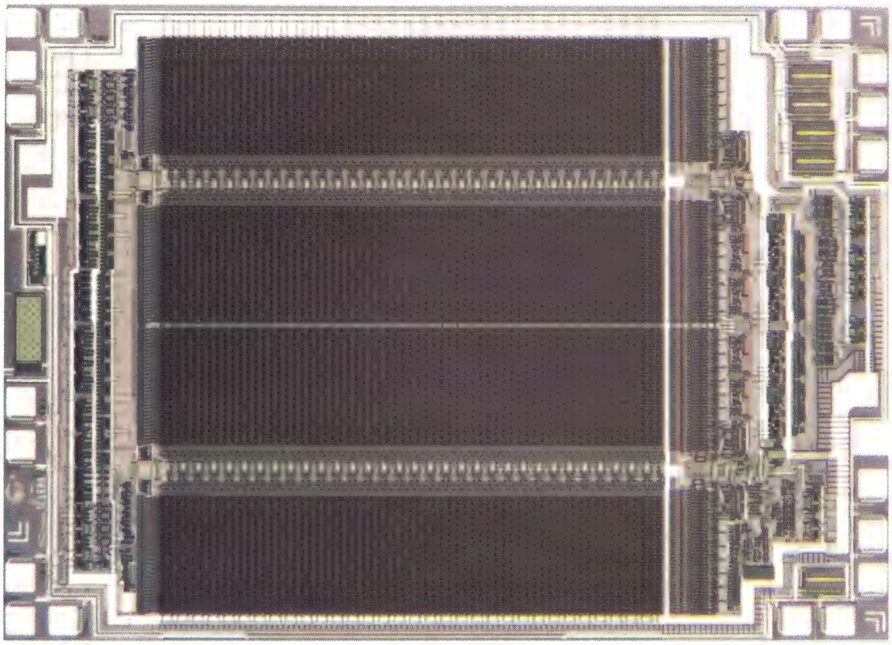
Process improvements and special features reduce high-end static-RAM access times

Maury Wright, *Western Editor*

Today's fast 16k- and 64k-bit MOS static RAMs have seen their access times fall to the 25- to 35-nsec range, approaching the speeds of ECL static RAMs. Furthermore, these devices offer such features as output-enable pins, separate I/O, reduced chip-select access times, and reset functions, allowing board- and system-level designers to achieve further reductions in effective access time. You will find a larger variety of these specialized features in 16k-bit offerings; manufacturers have only just begun to enhance the fast 64k-bit static RAMs.

These improvements in fast static RAMs allow designers the luxury of employing low-cost, high-density MOS static RAMs in applications traditionally served only by ECL memories. Such applications include caches, communications, imaging systems, control stores, and data-acquisition systems. Some applications require absolute chip-access times substantially less than 25 nsec and therefore must employ ECL memories. ECL offerings, however, typically provide only 1k- or 4k-bit densities, so you might find you need more chips to fulfill your memory requirements. Many designers are restructuring system architectures to use the 25-nsec MOS memories, even in minicomputer and mainframe caches.



Sub-35-nsec 16k-bit static RAMs *from Cypress include ICs with ×1 and ×4 organizations. The CY7C168 is a 4k×4-bit device that specs a 25-nsec access time.*

MOS RAMs for non-MOS μPs

Some applications that have traditionally called for ECL memories don't use a processor based on ECL ICs; chances are fast MOS static RAMs will fit your needs here as well. The propagation delay in a buffer between an ECL memory and a MOS processor diminishes the access-time improvement over MOS devices that ECL memories normally would confer. Meanwhile, the special features that effectively reduce access time ease integration of MOS static RAMs into these applications.

Until recently, a static RAM was regarded as "fast" by virtue of its application; ie, it was fast if you used it with a non-MOS μP, according to Lane Mason, senior industry analyst for Dataquest Inc (San Jose, CA). The MOS μPs were too slow to utilize effectively the speeds of the fast static RAMs. Now, Mason admits, that characterization must change. Fast MOS static RAMs turn up in increasing numbers of designs based on MOS μPs or MOS bit-slice processors. New μPs with 8-, 16-, and 32-bit data paths feature clock rates approaching 20 MHz. General-purpose computer designs with such high-performance μPs can use the fast static RAMs for a cache.

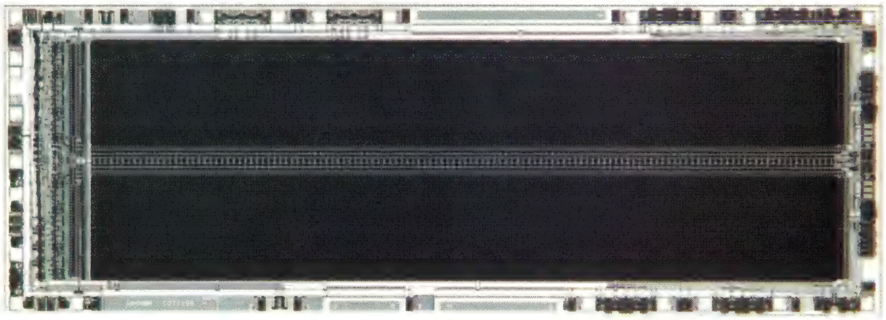
Designs with an embedded μP often require faster access than the system CPU itself actually demands. For example, an imaging system may require that a special-purpose controller read memory faster than the CPU can access the same shared memory. Today's MOS static RAM prove useful in these applications as well.

Static RAMs primarily feature either ×1 ("by 1"), ×4, or ×8 organizations. Typically, the popularity of a particular package and organization leads to a de facto standard, often followed by JEDEC imprimatur. JEDEC publishes official standards for the static-RAM packages and pinouts.

The commodity market for static RAMs (ie, for slower, low-cost devices produced in large quantities)

centers on ×8 organizations, for which there are established industry standards. Industry standards also exist for ×1 and ×4 parts. Manufacturers of fast static RAMs use standard organizations and packages whenever possible, but many of the special features found in fast static RAMs require some diversion from a standard. For example, a reset function requires an additional input not found on a standard static RAM.

Applications that simply require the improved densities and speeds benefit from the availability of standard sub-35-nsec static RAMs from many sources. Choosing a memory with a special feature may limit you to a single source. Because the special features simplify the static RAMs' integration into specific applications, designers must balance tradeoffs between simplicity of design and multiple sources.



This industry-standard, 35-nsec, 16k×4-bit static RAM, *the IDT7188 from Integrated Device Technology, comes in nonstandard versions that provide special features for reduced effective access time.*

Sub-35-nsec parts fall to $10

At the level of 16k-bit densities, industry-standard fast MOS static RAMs have dropped to $10 to $35 in OEM quantities. For example, Cypress offers the 16k×1-bit CY7C167 and the 4k×4-bit CY7C168 static RAMs, each featuring a 25-nsec access time. The former costs $18, the latter $19.50 (100). In quantities of 5000, the industry-standard 4k×4-bit IMS1423 from Inmos drops to $12. Lattice Semiconductor also provides standard, 25-nsec, CMOS static RAMs in 16k-bit densities. The 4k×4-bit SR16K4 costs $22 and the 2k×8-bit SR16K8 sells for $25 (1000).

For 16k- or 64k-bit, NMOS or CMOS static RAMs, the access time determines the price. Access times for the static RAMs described here are minimum figures; most vendors that offer 25-nsec parts also offer slower parts, and you may specify a memory that's 10- to 20-nsec slower for cost savings approaching 50%.

As an example of such cost savings, consider some 16k-bit offerings that spec 35-nsec min access times. Vitelic's 16k×1-bit V61C67, 4k×4-bit V61C68, and 2k×8-bit V61C16 static RAMs cost $11, $12.76, and $14.51 (100), respectively. These CMOS ICs suit low-power and battery-backup applications. In active mode, the ×8 static RAM consumes 200 mW, and the ×1 and ×4 offerings consume 150 mW. All devices consume 0.5 μW in standby mode and 0.1 μW in a low-voltage data-retention mode. In the low-voltage mode, the ICs retain data when powered from a 2V supply.

For applications that are less power sensitive, NMOS 16k-bit fast static RAMs do the job and cost less than the CMOS parts. Toshiba currently offers the 2k×8-bit TMM2018 and the 4k×4-bit TMM2068 NMOS static RAMs, which spec 35-nsec access times. Both parts consume 825 mW when active and 110 mW in standby mode. The parts cost $10 and $8.30 (100), respectively, and they come in industry-standard configurations.

A number of 16k-bit static RAMs implement special features that trim the memories' effective access times. Toshiba's 4k×4-bit static RAM, for example, furnishes an output-enable pin. The 35-nsec TMM2078 comes in a 22-pin package and costs $9.90 (100). All of the 16k-bit Toshiba parts will achieve 25-nsec access times in the second or third quarter and will cost 10 to 20% more.

According to Jim Townsend, strategic marketing manager at Toshiba, the output-enable feature improves system speed by 5 to 10 nsec. The output enable allows you to design a board architecture that frees the bus faster than standard 4k×4-bit static RAMs can (the standard parts use common-I/O pins, ie, input and output data are on the same pin). A typical board architecture employs parallel data lines from multiple static RAMs. During a read operation, a single RAM ties up the bus until the processor removes the input address to the static RAM. If implemented in the board design, a static RAM with output enable will release the bus upon completion of the read operation and before the static RAM is deselected.

An industry-standard ×4 package requires 20 pins without the output enable; no standard currently exists for ×4 parts with the output-enable feature. Industry-standard static RAMs typically implement output enable on all ×8 designs. Because such devices have eight data lines on a single IC, the output-enable feature simplifies device timing.

Another useful feature is separate data I/O. In the case of ×1 devices, the provision of separate I/O lines only requires one extra pin. Separate I/O provides an optimum configuration, and the industry accepts the 1-pin penalty. Industry standards to date do not include separate I/O for ×4 static RAMs, but the need for improved speeds and densities is leading designers to demand such features, despite the additional cost.

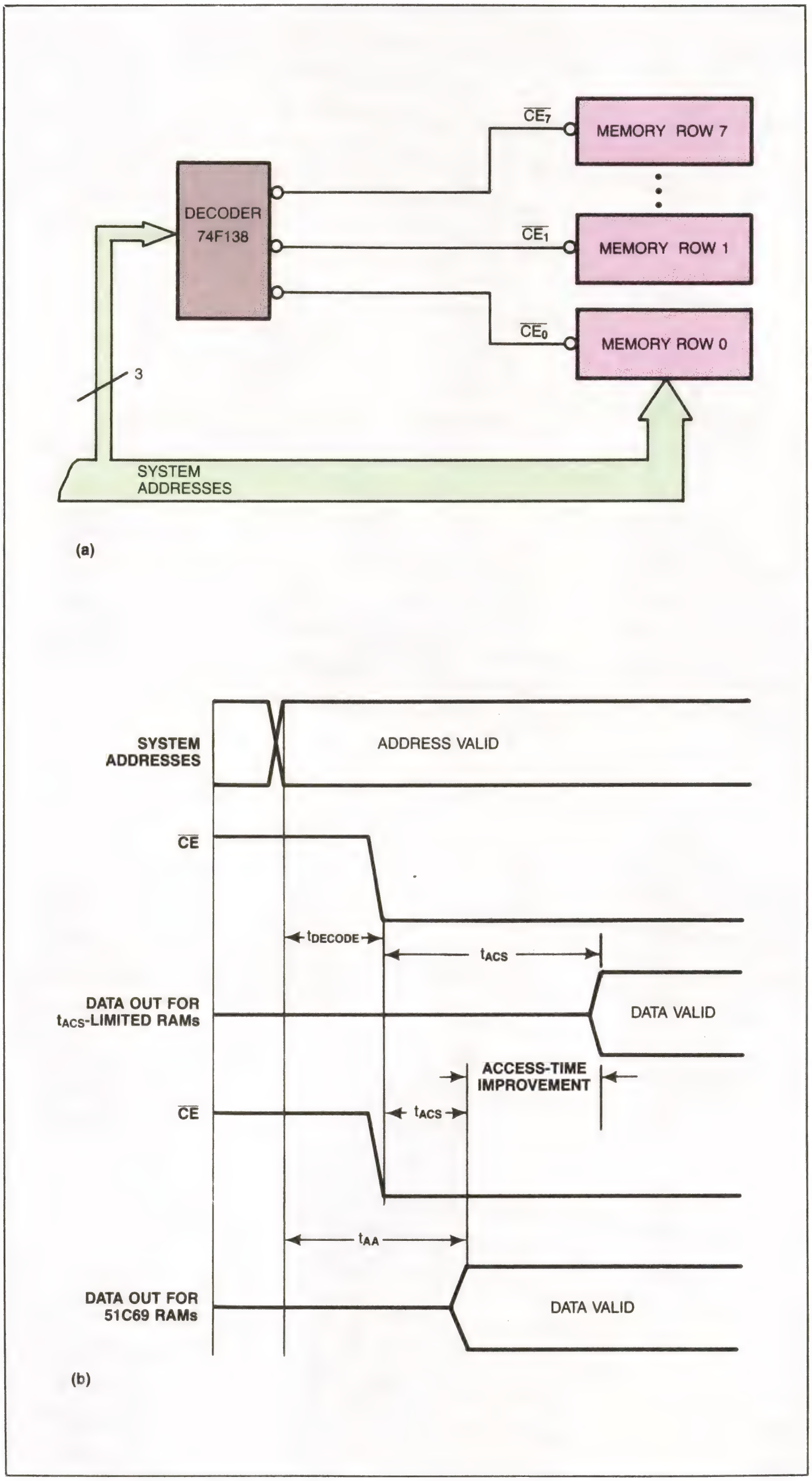


***Fig 1—A 15-nsec chip-select access time** (t_{ACS}) and 25-nsec address access time (t_{AA}) allow Intel's 51C69 static RAMs to hide the 10-nsec propagation delay (t_{DECODE}) of a 74F138 decoder; the system in **a** yields a 25-nsec system access time. In many such RAMs, the chip-select access time equals the address access time, yielding a system access time that equals the chip-select address time plus the decoder delay. In the system shown here **(a)**, the Intel chips yield a 10-nsec system access time improvement **(b)**.*

Integrated Device Technology offers the 25-nsec, 4k×4-bit IDT71681 and IDT71682, each of which costs $38 (100) and includes four extra pins for separate outputs. The IDT71681 provides a high-impedance state at each output during a write operation. The outputs track the inputs during a write operation on the IDT71682 static RAM.

This input tracking, also referred to as a transparent write, allows ICs on the output side of the static RAM to monitor the addressed RAM location. The transparent-write feature suits systems requiring a read verification of data after each write operation. Verification occurs simultaneously with the write operation.

Integrated Device Technology also offers industry-standard 25-nsec 4k×4-bit, 35-nsec 2k×8-bit, and 25-nsec 16k×1-bit static RAMs. These parts are the $35 to $38 (100) IDT6168, IDT6116, and IDT6167, respectively. All IDT fast static RAMs employ a CMOS process with a 2V data-retention mode.

The separate-output and output-enable features essentially reduce access time at the system level. Intel takes a more direct approach toward improving access times. The company's designers have reduced the absolute access time from activation of the chip-select signal to the appearance of valid data at the outputs of the 16k×1-bit 51C66 and 4k×4-bit 51C69. Cypress provides an identical feature on the 4k×4-bit CY7C169 static RAM, which costs $19.50. The 51C66 and 51C69 cost $18 and $19.80 (100), respectively.

Semiconductor manufacturers typically distinguish between two types of read cycles when measuring access times. In one case, the address lines stabilize before the chip-select input goes active—for example, when high-order bits needed to address several banks of RAM must go to a decoder before activating the chip-select pin. In the second case, the address lines stabilize after chip select is activated. **(Fig 1)**.

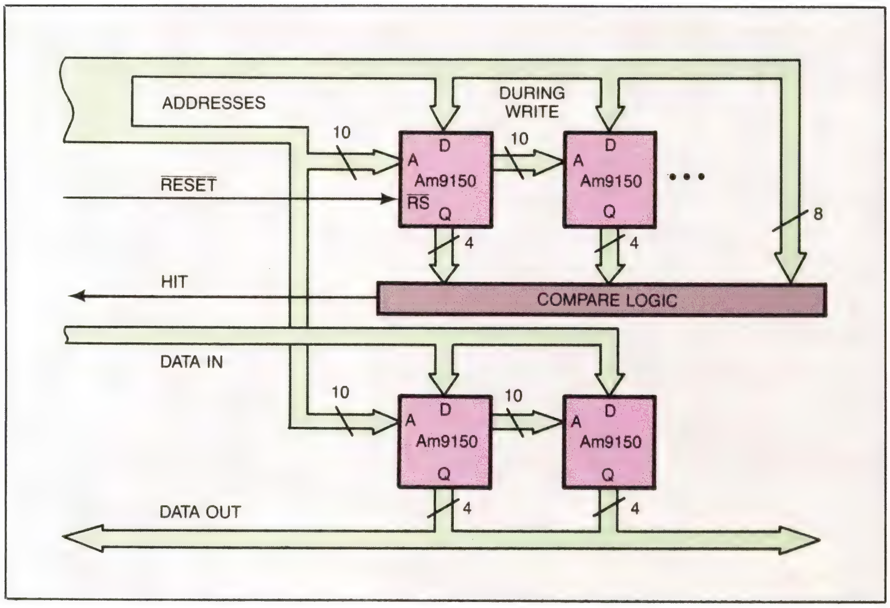


***Fig 2—A static RAM with a reset function**—AMD's Am9150, for example—can serve as a tag buffer in a cache-memory system that requires initialization on context switches.*

Most manufacturers spec the same access time for both types of read cycle, because they measure it from the last event that occurs, whether it's chip-select activation or address-line stabilization. In the first case, however, the access time will actually be longer, because the chip-select decoding time has been ignored.

Intel's 51C66 and the 51C69 furnish the same real access time regardless of the type of read cycle employed. When address stabilization is the last event, the static RAMs furnish a 25-nsec min access time. When the addresses stabilize before chip-select, however, the memories effectively hide the typical 10-nsec propagation delay associated with chip-select decoding, and they reduce the access time from chip-select to data-valid to 15 nsec.

Other fast static RAMs from Intel are the 16k×1-bit 51C67 and the 4k×4-bit 51C68. The parts spec 30-nsec access times and provide a low-voltage mode but not reduced chip-select access time. They cost $16.25 and $17.88 (100), respectively. All the Intel parts feature industry-standard pinouts.

Another special static-RAM feature that improves system or software performance is a reset pin for a clear function. The task of clearing a standard static RAM requires very little software, but a loop must execute once for every location in the RAM array. Even a memory as small as 4k bytes, with write cycle times of approximately 50 nsec, wastes 200 μsec when doing no more than writing zeros to memory. Communication and data-acquisition applications often require the clearing of much larger memory banks. Static RAMs with the reset capability clear the memory in one cycle.

Another application of the reset function, a tag buffer for cache memory, requires memory initialization on power-up, context switches, and other operations. The tag buffer stores information that refers to main-memory addresses that are mapped into the cache. When executing a given instruction, the processor produces a physical address, and the cache controller must determine if the address currently resides in the cache. The cache controller checks the tag buffer and fetches the required address from main memory if it does not already reside in the cache.

The tag buffer requires initialization on context switches or other operations requiring major cache content changes. Without intialization, the cache controller may mistakenly determine that the cache contains a given address. The reset function allows the processor to clear the tag buffer without wasting the time required to zero each buffer location.

Static RAM clears in 40 nsec

Advanced Micro Devices implements the clear function on the 1k×4-bit Am9150 static RAM. **Fig 2** illustrates the use of AMD Am9150s in a cache application. An active signal applied to the reset pin will clear the RAM in 40 nsec. The device features separate I/O and a 20-nsec access time. It costs $24.95 (100). Later in the year, AMD plans to implement the reset feature in higher-density memories.

When designing static RAMs with densities greater than 16k bits, manufacturers tend to concentrate more on speed and cost than on special features. Actually, manufacturers have only recently begun to ship fast 64k-bit static RAMs. Even so, the designs are maturing rapidly, and a few 64k-bit memories provide added features that reduce effective access times.

Manufacturers initially designed sub-35-nsec 64k-bit static RAMs with ×1 organizations, but parts with ×4 and ×8 organizations are starting to appear. Hitachi, for instance, initially offered only a part with a ×1 organization. The 64k×1-bit HM6787 was followed shortly by the 16k×4-bit HM6788.

Mixed process smooths access

The two static RAMs cost approximately $40 each (10,000) and employ Hitachi's Hi-BiCMOS process. This process mixes bipolar and CMOS technologies in a single IC. The RAM designs employ CMOS circuitry in the RAM array, and bipolar technology at the outputs contributes to the devices' 25-nsec

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access times. The static RAMs consume 300 mW when active and 20 mW in standby mode.

IDT currently offers the industry-standard 16k×4-bit IDT7188 and 64k×1-bit IDT7187 static RAMs, which spec 35-nsec access times and cost $100 (100). The company also provides three variations to the standard 16k×4-bit design. The $100 (100) IDT7198 includes an output-enable pin and an extra chip-select pin. The additional chip-select pin simplifies decoder circuitry. The IDT71981 and IDT71982 each cost $100 (100); both provide separate I/O, and the former employs an output that tracks the input. Like IDT's 16k-bit static RAMs, the 64k-bit parts include a low-voltage mode.

Cache tag adds compare logic

Around midyear, IDT plans to introduce some 8k×8-bit parts. One will be an industry-standard part, another (the IDT7165) will have a reset function, and a third (the IDT7174) will be a cache-tag device. The cache-tag part will include a reset function and a compare output for tag-buffer applications. The initial offerings will feature 45-nsec min access times, but process tuning should quickly bring the access times down to 35 nsec.

Lattice's 64k-bit static-RAM family already includes 35-nsec ×8 ICs in addition to ×4 and ×1 parts. The $37.50 SR64K1 is an industry-standard 64k×1-bit memory. The $55 16k×4-bit choices include a standard SR64K4 part in a 22-pin package and the SR64E4 with output enable in a 24-pin package. The 8k×8-bit SR64K8 costs $60 (1000).

Cypress plans to introduce two families of fast 64k-bit static RAMs in the second quarter. Each family will contain parts with the same organizations and features but slightly different process technologies. The CY7CXXX family will be a continuation to 64k bits of the company's 16k-bit CMOS static RAMs. The CY8CXXX family will implement Cypress's new BridgeMOS process, which employs CMOS cells with output drivers optimized for TTL or CMOS interfaces. All products in both families will feature 25-nsec access times.

The 64k-bit families will include members with ×1, ×4, and ×8 or-

For more information . . .

For more information on the static RAMs discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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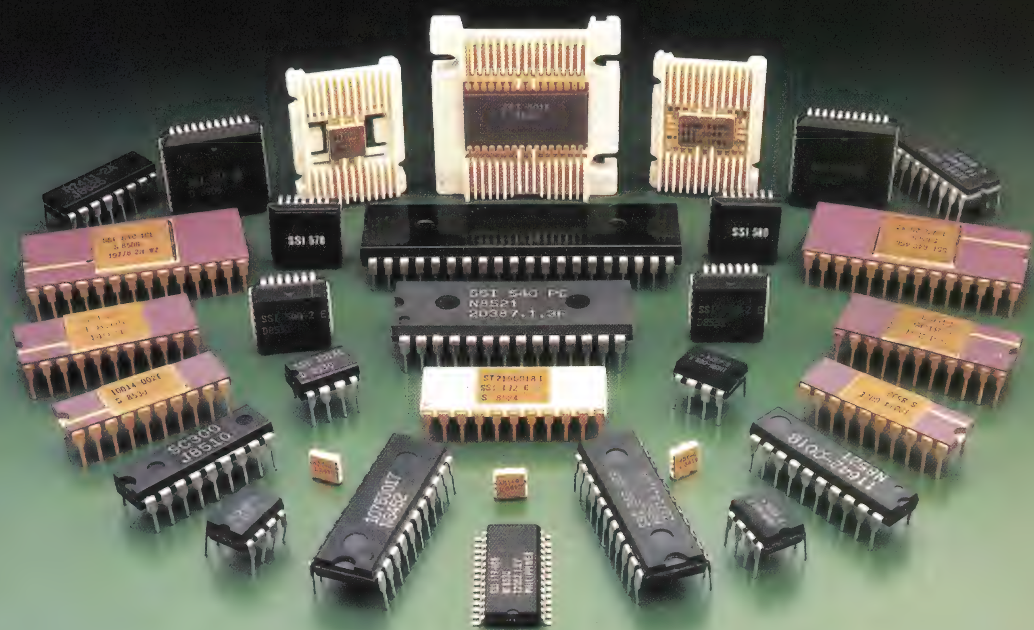

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ganizations. The 16k×4-bit variations will include versions with an output-enable function, with separate I/O, and with separate I/O and a transparent-write function. The 8k×8-bit memory will come in a 28-pin, 300- or 600-mil-wide package. Prices for the industry-standard CY7CXXX parts will range from $40 to $85 for the 64k×1-bit CY7C187 and from $60 to $125 (1000) for the 8k×8-bit CY7C186.

Prices for the CY8CXXX BridgeMOS family will typically be 15 to 25% greater than prices for the CMOS parts. The BridgeMOS process renders the RAMs compatible with different logic families. Some standard CMOS static RAMs sacrifice optimum CMOS drive capabilities to remain TTL compatible. The BridgeMOS static RAMs maintain TTL compatibility and drive CMOS circuits from rail to rail.

Parity added in ×9 static RAM

Toshiba will introduce a byte-wide 64k-bit part before it introduces 64k-bit static RAMs with other organizations. The company's first 35-nsec offering will actually be a 72k-bit static RAM with an 8k×9-bit organization. The TMM2089 reflects Toshiba's plans to migrate from ×8 to ×9 organizations for all byte-wide static RAMs.

Consumers of commodity static RAMs have been begging for a parity bit in high-density parts. Because JEDEC standards for byte-wide static RAMs leave an open pin, Toshiba's ×9 parts can supply the parity bit and still maintain compatibility with industry standards. Users requiring only eight bits can leave one data bit unconnected. The ninth bit increases cost because of an increase in the size of the silicon array. Toshiba believes, however, that by not building distinct ×8 and ×9 parts, higher manufacturing volumes will offset the cost difference.

The TMM2089 will cost $35 (100), and the company plans to have samples available in this quarter. The company also plans to have samples of two 25-nsec 16k×4-bit CMOS static RAMs in the third quarter. The TC55416 with common I/O and the TC55417 with an output-enable pin will both cost approximately $28 (100).

As fast static RAMs move into the applications once reserved for ECL devices, so will improved dynamic RAMs take over some traditional static-RAM applications. Designers have preferred static RAMs because of speed advantages, but dynamic-RAM manufacturers have implemented such special modes as the nibble mode and static-column addressing to lower access times to the 50-nsec range.

Dynamic RAMs also cost less than static RAMs, though the former require refresh circuitry. When memory requirements are small, the attendant refresh circuitry can be as costly as the memories themselves. For large amounts of memory, however, the cost of refresh circuitry is distributed over many parts, and the advantage of dynamic RAMs emerges.

Another threat to the traditional static-RAM realm is Visic's hierarchical RAM (HRAM) family, the members of which spec 35-nsec access times. Visic expects that, by midyear, the 64k×1-bit V64H1 and the 16k×4-bit V1HH4 will cost less than $20 (1000). All HRAMs feature 25-nsec static-column access times, and the ×1 part includes a 4-bit snap mode with 10-nsec read cycles (the snap mode is similar to the nibble mode in a dynamic RAM). The company also recently introduced the $30 8k×9-bit V8K9 HRAM, which has a built-in parity checker. Like the dynamic RAM, the HRAM requires refresh circuitry, but it still can compete in static-RAM markets. **EDN**

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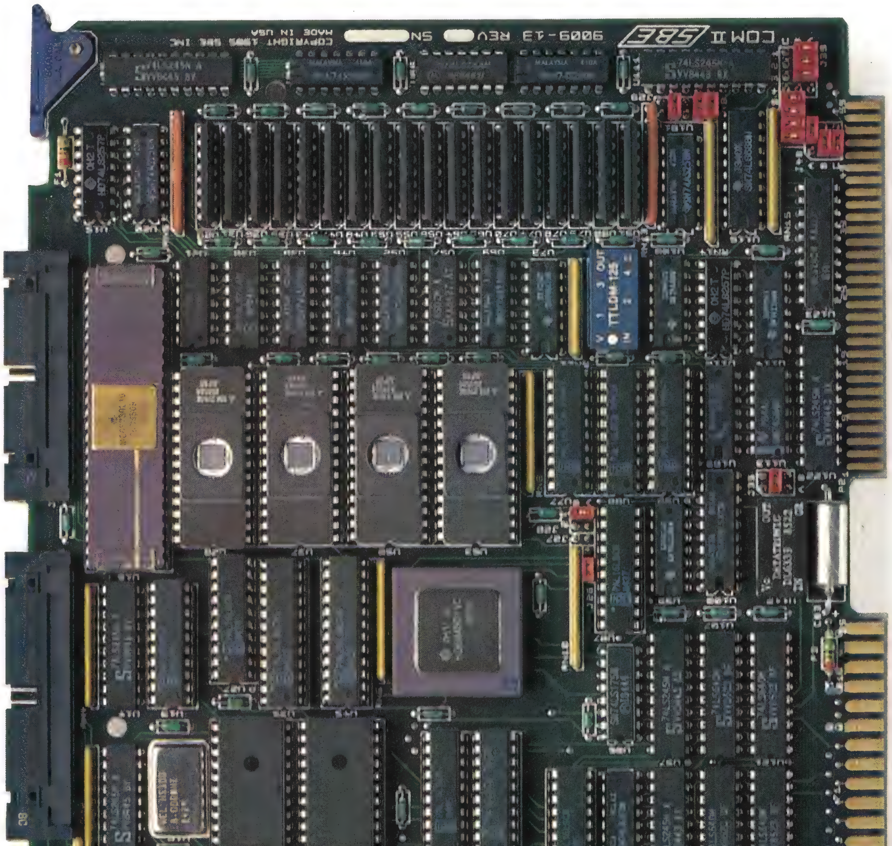

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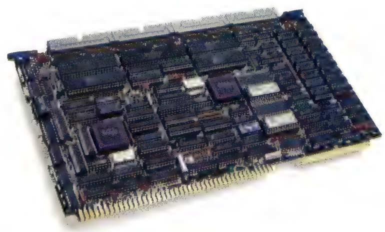

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Digitizing tablets offer choices of formats, operating modes, and pointers

Jon Titus, *Senior Editor*

Whether you're digitizing schematic diagrams, data plots, mechanical drawings, or a 3-dimensional shape, you can choose from a variety of digitizing tablets, pointing devices, and output formats to fit your needs. Nevertheless, you must consider the resolution and accuracy necessary for your application as well as hardware and software compatibility—for after all, tablets transfer their data to computers.

Digitizing tablets—most of which are 2-dimensional—use electrical fields, sounds, or resistances to locate a point on a flat surface and convert it to a set of X and Y coordinates that a computer program can process. To digitize graphic information, you mount a drawing, schematic diagram, or other graphic information on the tablet's work surface and move a stylus from point to point. After moving the stylus to a new point, pressing a button causes the digitizer to output the point's X and Y coordinates.

To decide what type of digitizer your application will require, consider the information you're digitizing, and thus the resolution you'll need. For instance, digitizing fine lines on a scaled mechanical drawing requires more resolution than digitizing general building locations on a map. Typical resolutions range from 100 to greater than 1000 lpi, or from 0.010 in. to less than 0.001 in. Tablets in Summagraphics' MM Series, for example, let you preset a resolution that ranges from 100 to as many as 1000 lpi. Thus, programs can select the resolution that best suits specific digitizing needs.

A tablet's accuracy specification lets you know how well it locates the actual coordinates of a point on its surface. The amount of accuracy you get depends on how much money you're willing to spend. Tablets under \$1000 provide an accuracy of about ±0.025 in., whereas more expensive tablets offer accuracies as great as ±0.003 in. (**Table 1**).

Of course the price you'll pay doesn't just hinge on the accuracy you specify: You'll also confront many tablet sizes, mounting styles, and options. Tablets range from 6×6 in. to greater than 60×72 in. You can buy tablets that sit on desk tops, have their own floor stands, mount on walls, or fit in desk-top cutouts.

Most digitizers provide either opaque or translucent work sur-

If you have a clear tablet, *you can place it over artwork or other data for digitizing. For example, you can use this Scriptel tablet over a CRT screen to digitize graphic data accurately or to make menu selections.*

TABLE 1—REPRESENTATIVE DIGITIZING TABLETS

MANUFACTURER	MODEL	SIZE RANGE (IN.)	RESOLUTION	ACCURACY	INTERFACE	DIAGNOSTICS	POINTERS
ALTEK	DATATAB	12×12 TO 42×130	0.001 IN.	±0.01 TO ±0.003 IN.	RS-232C	YES	STYLUS CURSOR
ARISTO GRAPHICS	SERIES-200	20×20 TO 40×60	0.001 IN.	±0.001 IN.	RS-232C	YES	STYLUS CURSOR
CALCOMP	2200 SERIES	12×12 AND 12×18	200 LPI	±0.025 IN.	RS-232C	NO	STYLUS CURSOR
	9100 SERIES	17×24 TO 44×60	1279 LPI OR 50 LINES/mm	±0.01 IN.	RS-232C IEEE-488	NO	STYLUS CURSOR
COMPUTER TALK	MODEL 600	TO 8×10 FT	0.01 TO 0.001 IN.	±0.01 TO ±0.005 IN.	RS-232C	YES	CURSOR
GTCO	TYPE 5A	11×11 TO 42×60	0.001 IN. OR 0.025 mm	±0.01 TO ±0.003 IN.	RS-232C	YES	STYLUS CURSOR
HEWLETT-PACKARD	9111A	8.6×11.8	0.10 mm	±0.6 mm	IEEE-488	NO	STYLUS
HITACHI	HDG SERIES	11×11 TO 44×60	0.001 IN.	±0.01 TO ±0.005 IN.	RS-232C IEEE-488 PARALLEL TTL	YES	STYLUS CURSOR
HOUSTON INSTRUMENT	SERIES-1000	5×5 TO 11×17	0.005 IN.	±0.015 IN.	RS-232C	YES	CURSOR
	SERIES-8000	11×11 TO 24×36	0.001 IN.	±0.01 IN.	RS-232C	YES	CURSOR
MICRO CONTROL SYSTEMS	PERCEPTOR	40×31×38	0.007 TO 0.010 IN.	0.007 TO 0.02 IN.	RS-232C	NO	STYLUS
NUMONICS	2200 SERIES	6×6 TO 36×48	0.001 IN. OR 0.025 mm	±0.01 TO ±0.005 IN.	RS-232C IEEE-488 PARALLEL TTL	YES	STYLUS CURSOR
SCIENCE ACCESSORIES	GP-7	18×24 20×26	0.01 IN. OR 0.01 cm	±0.01 IN. OR ±0.01 cm	RS-232C PARALLEL TTL	NO	STYLUS CURSOR
	GP-8	24×24 TO 60×72	0.01 IN. OR 0.01 cm	±0.01 IN. OR ±0.01 cm	RS-232C PARALLEL TTL	NO	STYLUS CURSOR
	GP-8-3D	10×10×10 FT	0.01 IN. OR 0.01 cm		RS-232C PARALLEL TTL	NO	STYLUS
SCRIPTEL	SPD SERIES	12×12 TO 24×36	0.001 IN.	±0.025 IN.	RS-232C PARALLEL TTL	YES	STYLUS CURSOR
SUMMAGRAPHICS	MM SERIES	6×9 TO 11.7×11.7	0.001 IN.	±0.025 IN.	RS-232C	YES	STYLUS CURSOR
	MICROGRID	20×20 TO 42×60	0.001 IN.	±0.010 IN.	RS-232C IEEE-488 PARALLEL TTL	YES	STYLUS CURSOR
TEKTRONIX	TEK-4957	11×11	0.001 IN.	±0.025 IN.	RS-232C	YES	STYLUS CURSOR
	TEK-4958	17×24 TO 36×48	0.001 IN.	±0.01 IN.	RS-232C	YES	STYLUS CURSOR

faces. You can also buy backlit tables that light negatives, x-rays, film drawings, and other transparent or translucent media. Scriptel Corp's SPD Series tablets feature a clear position-sensing layer in a transparent glass carrier. Unlike opaque tablets, you can position the SPD Series tablets over original material you want to digitize. You can also put the tablet on a light table or over a display screen to digitize data.

All digitizing tablets provide an origin for the X and Y coordinates. Tablets like the Numonics Model 2200 let you move the origin to any point on the tablet's work area. A programmable origin lets you set a consistent starting point for each digitizing task. The Summagraphics MM Series and the Hitachi HDG Series tablets let you fix the origin at one of two adjacent tablet corners. Thus, you can maintain the same coordinate orientation when you rotate the tablet 90°.

Once you've set a tablet's origin, you trace lines or locate points with a stylus. Pressing a button on the stylus sends your computer the point's X and Y coordinates. You can select a plain stylus point or one with a pen in it. The pen marks the points and lines you've digitized. Pen points are replaceable and interchangeable with nonmarking points. Because stylus tips aren't very fine, the points you locate with

ORIGIN RELOCATION	OUTPUT MODES: POINT	STREAM	INCREMENT	SWITCHED STREAM	POLLED	BASE	NOTES	PRICE
YES	•	•	•	•	•	OPAQUE BACKLIT	CHOICE OF TWO CONTROLLERS	$4000 FOR 36×48 IN.
NO	•	•	•		•	OPAQUE	RS-423 OPTIONAL INTERFACE	FROM $11,000
NO	•	•		•		OPAQUE		FROM $695
NO	•	•	•	•	•	OPAQUE BACKLIT	REAR PROJECTION RS-449	FROM $3800
YES	•					OPAQUE BACKLIT	TABLETS CUSTOM BUILT TO CUSTOMER SPECIFICATIONS	FROM $2500
NO	•	•	•			OPAQUE		FROM $995
NO	•	•				OPAQUE BACKLIT	MENU MODE	FROM $2275
YES	•	•	•	•	•	OPAQUE BACKLIT	TWO ORIGIN POSITIONS	FROM $973
YES	•	•	•	•	•	OPAQUE	TWO ORIGIN POSITIONS	FROM $495
YES	•	•	•	•	•	OPAQUE		FROM $1150
NO	•	•	•		•	N/A	5 POINTS PER SECOND 3 DIMENSIONAL	$9500
YES	•	•	•	•	•	OPAQUE	MENU MODE	FROM $859
YES	•	•		•	•	N/A	ANY FLAT SURFACE	FROM $1000
YES	•	•		•	•	N/A	ANY FLAT SURFACE	FROM $1000
NO	•	•			•	N/A	3 DIMENSIONAL	FROM $7500
YES	•	•	•	•	•	CLEAR	CLEAR BASE	FROM $1095
YES	•	•	•	•	•	OPAQUE	TWO ORIGIN POSITIONS	FROM $999
YES	•	•	•	•	•	OPAQUE		FROM $2524
YES	•	•	•	•	•	OPAQUE	MENU MODE	$995
NO	•	•				OPAQUE	MENU MODE	FROM $4500

them may not give you the accuracy you need or expect from your tablet.

To increase your measuring accuracy, you can use a handheld cursor or puck, which you move across the digitizer's surface. The cursor contains a reticle and at least one pushbutton. The reticle's fine cross hairs help you accurately locate each point for digitizing. Pressing the cursor's button sends the coordinates at the cross hairs to the computer. Depending on your software's capabilities, and the number of available buttons on the cursor, you can assign each button a specific command or operation. For example, you can use the buttons to let the computer know whether you're digitizing points or selecting alphanumeric font sizes or electronic symbols.

Serial formats aren't standard

Almost all digitizing tablets communicate with host computers through standard RS-232C I/O ports. Keep in mind, however, that the RS-232C specification defines the signal lines, not the data's format. Most manufacturers let you select either an ASCII or a packed-binary data format for the X-Y-coordinates and the pushbutton information the tablet sends to the computer. Nonetheless, ASCII and packed-binary data formats vary from manufacturer to manufacturer, so before you select a tablet that

(a) $X_1\ X_2\ X_3\ X_4\ X_5\ Y_1\ Y_2\ Y_3\ Y_4\ Y_5$ PB CR LF

(b) PB SG $X_1\ X_2\ X_3\ X_4\ X_5$ SP SG $Y_1\ Y_2\ Y_3\ Y_4\ Y_5$ CR LF

(c) $X_1\ X_2\ X_3\ X_4\ Y_1\ Y_2\ Y_3\ Y_4$ SB CR LF*

PB = PUSHBUTTON-STATUS BYTE
SG = SIGN BYTE
SB = STATUS BYTE
SP = SPACE
CR = CARRIAGE RETURN
LF = LINE FEED

* LINE-FEED BYTE OPTIONAL

***Fig 1—Digitizing tablets output ASCII transmissions** that vary from manufacturer to manufacturer. The Scriptel SPD format **(a)** supplies 13 data bytes, whereas the Numonics format **(b)** supplies 16 bytes. Calcomp's 2200 Series tablets **(c)** let you select a 10- or an 11-byte format.*

otherwise meets your needs, be sure your software accepts the tablet's data format.

For example, if your software operates with coordinates sent in Scriptel's SPD ASCII format, the computer expects to receive 10 X-Y-coordinate bytes and subsequent pushbutton-status, carriage-return, and line-feed bytes (**Fig 1**). The software won't operate properly if you send the computer data from a Calcomp 2200 Series digitizer. The Calcomp unit transmits only eight X-Y-coordinate bytes, followed by status, carriage-return, and line-feed bytes.

A packed-binary format requires fewer bytes for RS-232C transmissions, but again packed-binary data formats vary (**Fig 2**). A few manufacturers offer parallel TTL or IEEE-488 interfaces instead of an RS-232C port. If you can't easily reconfigure your software for a particular data format or I/O interface specification, check the software's documentation for a list of compatible tablets.

To help you circumvent the data-compatibility problem, Scriptel's SPD Series tablets let you select, under software control, any one of 13 common data formats. Likewise, Hewlett-Packard furnishes an extensive set of support hardware and

CALCOMP BINARY FORMAT

BYTE \ BIT	7	6	5	4	3	2	1	0
1	P	1	D	C	B	A	0	0
2	P	0	X_5	X_4	X_3	X_2	X_1	X_0
3	P	0	X_{11}	X_{10}	X_9	X_8	X_7	X_6
4	P	0	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0
5	P	0	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6

P = PARITY
A,B,C,D = PUSHBUTTONS

NUMONICS BINARY FORMAT

BYTE \ BIT	7	6	5	4	3	2	1	0
1	1	PS	B_8	B_4	B_2	B_1	X_{15}	X_{14}
2	0	X_{13}	X_{12}	X_{11}	X_{10}	X_9	X_8	X_7
3	0	X_6	X_5	X_4	X_3	X_2	X_1	X_0
4	0	0	0	0	0	0	Y_{15}	Y_{14}
5	0	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7
6	0	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0

PS = PEN DEPRESSED OR SWITCH 0 ACTIVE
B_N = PUSHBUTTON BINARY CODE

SCRIPTEL BINARY FORMAT

BYTE \ BIT	7	6	5	4	3	2	1	0
1	1	0	0	0	B_4	B_3	B_2	B_1
2	0	0	0	0	0	SG	X_{15}	X_{14}
3	0	X_{13}	X_{12}	X_{11}	X_{10}	X_9	X_8	X_7
4	0	X_6	X_5	X_4	X_3	X_2	X_1	X_0
5	0	0	0	0	0	SG	Y_{15}	Y_{14}
6	0	Y_{13}	Y_{12}	Y_{11}	Y_{10}	Y_9	Y_8	Y_7
7	0	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0

B_N = PUSHBUTTON DATA BITS
SG = SIGN BIT

***Fig 2—Packed-binary data formats for tablets** offer faster transmission speeds than ASCII formats. However, manufacturers' formats differ.*

software that links its Model 9111 digitizer and HP computers over an IEEE-488 bus. However, before you can use the 9111A tablet with non-HP computers that support an IEEE-488 interface, you must develop your own driver routines.

Tablets offer menu selections

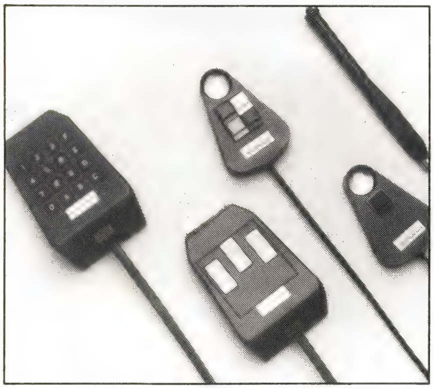
Although users most frequently employ tablets to digitize graphic information, you can also use a tablet to select menu items. For this task, you won't need high accuracy or resolution: The computer simply needs to know you're pointing to a selection within a defined area.

You have two ways of selecting menu items. You can use the cursor like a mouse, moving a pointer on the computer's display screen, or you can use the cursor to select items from a printed menu on the tablet's work surface. One advantage of using printed tablet menu items is that you can see all the selections at once, without switching between screen menus.

Thus, although tablets add to the cost of a computer system, they provide convenience and they don't obscure information on a monitor screen. The Numonics Model 2200 digitizer lets its host computer configure a set of menu-cell spaces in the work area. Likewise, you can specifically configure Tektronix's TEK-4957 tablet to operate in a menu-selection mode.

Besides letting you select menu-type operations, many tablets also let you select different types of data-output operations. Depending on your tablet, you can select point, stream, switched-stream, polled, and incremental operations.

In the point mode, you locate each point with the stylus or cursor and press a button to send the coordinates to the computer. When it's in



***Different types of digitizer pointing devices** let you select one that best meets your needs. Houston Instrument's multibutton cursors let you control computer operations from your tablet's surface without forcing you to use the computer's keyboard.*

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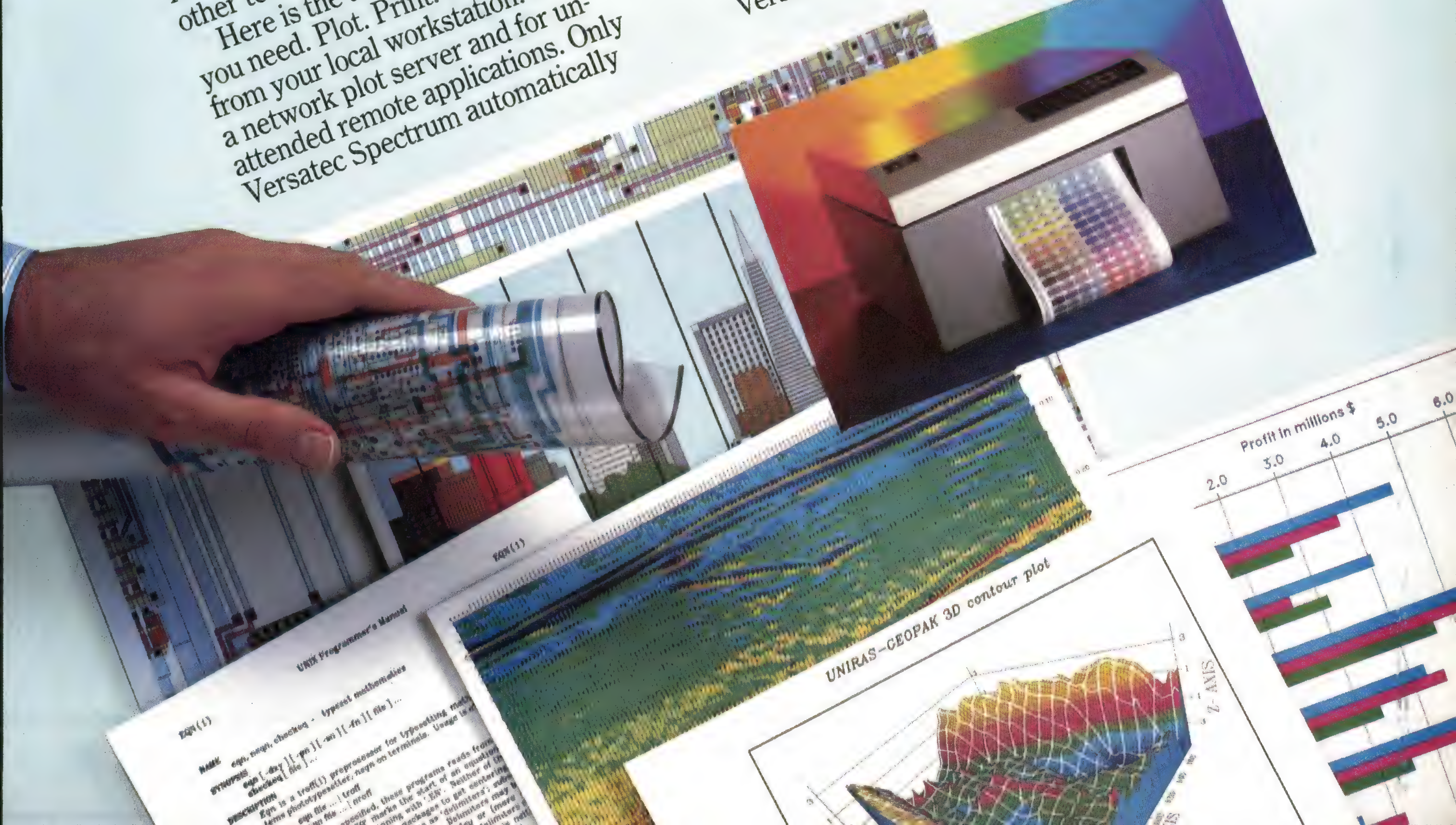
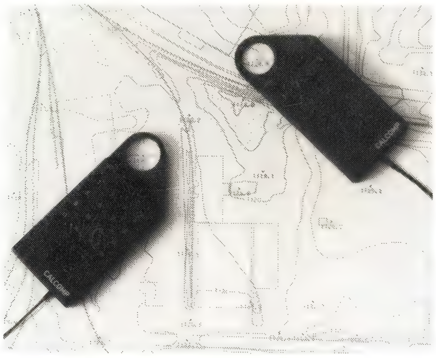


the stream mode, a tablet continuously transmits the cursor's coordinates to the computer. However, when you select the switched-stream mode, the tablet transmits the coordinate stream only for as long as you continue pressing the cursor's pushbutton.

In the polled mode, the tablet lets the computer's software request specific information about the cursor's location and the pushbuttons' status. The incremental mode sets a dead zone around the cursor. The tablet sends the computer new position information only after the cursor moves outside the dead zone.



A cursor's cross hairs let you accurately locate points *on your artwork. A cursor offers better resolution than a stylus with a blunt pointer. Calcomp's cursors provide four or 16 pushbuttons and four indicators.*

You can digitize 3-dimensional objects *by using Micro Control Systems' Perceptor. A captive stylus controls potentiometers that provide 3-D coordinates to a computer. The digitizing volume is 20,000 in.*^{3}

Because almost all digitizers are tied to a fixed electrically active base, their use is limited in some applications. In contrast, however, Science Accessories Corp's GP-7 and GP-8 sonic digitizers require only a flat surface and thus can serve special needs. For example, at Boeing Aircraft Corp, a GP-8 digitizer sits on a wiring-harness layout table and transmits connector and termination locations to a computer.

Instead of the tablet's base being electrically coupled to its cursor or stylus, a sonic digitizer uses a set of microphones to generate coordinates for the sound source in the stylus. The GP-7 digitizer module sits behind your graphic material and provides an 18×24-in. or 20×26-in. active work area. A narrow L-shaped case houses the GP-8 digitizer, which positions sensors along your work area's length and width. Standard work areas for the GP-8 range from 20×20 in. to as large as 60×70 in.

Also, because sonic digitizers don't depend on proximity to a special work surface, they can digitize 3-dimensional objects. However, such digitizers require extra microphones and control circuits. Science Accessories Corp's 3-dimensional digitizer operates within a 20×20×20-ft volume, providing a resolution of 0.01 in.

Micro Control Systems Inc also sells a 3-dimensional digitizer, Perceptor, but it has a different digitizing approach. Instead of using a freely moving sonic stylus, you locate points on an object's surface with a captive stylus. Potentiometers within the Perceptor's five mechanical joints let an internal microprocessor compute 3-dimensional Cartesian coordinates. **EDN**

For more information . . .

For more information on the digitizing tablets described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Altek Corp
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Silver Spring, MD 20904
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(201) 366-7000
Circle No 702

Calcomp
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Anaheim, CA 92801
(714) 821-2000
Circle No 703

Computer Talk Inc
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Morrison, CO 80465
(303) 697-5485
Circle No 704

GTCO Corp
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Rockville, MD 20850
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Hewlett-Packard
Box 10301
Palo Alto, CA 94303
Phone local office
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CIRCLE NO 43

ROHDE & SCHWARZ

3-4/86

NEWS FROM PHILIPS

INTEGRATED CIRCUITS □ SEMICONDUCTORS □ ELECTRON TUBES □ COMPONENTS □ ASSEMBLIES □ MATERIALS

COMPUTER-CONTROLLED CONNECTOR CIRCUIT CUTS CABLE CHANGE-OVERS

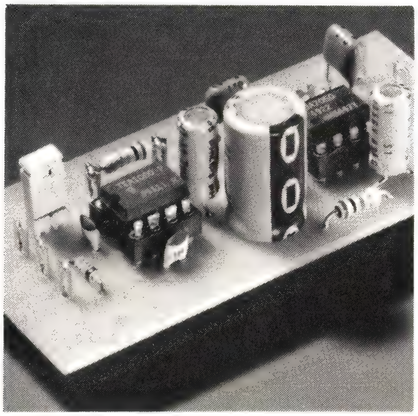
As part of our total computer-controlled television concept, we are supplying a versatile switching circuit for use with a peritelevision connector as specified by CENELEC. The TDA8440 offers flexibility and low-distortion performance unobtainable in discrete solutions. By performing peritelevision connector switching functions to select signal source under control of a microcontroller, the bipolar IC eliminates manual interchanging of cordsets at the rear of a display unit or tv set. Although communication is normally via the two-line serial I²C bus, non-I²C bus control is also possible. The circuit can also be controlled by the d.c. level on the function switching pin of the peritelevision connector.

The TDA8440 can select one of two video signals together with their stereo/dual sound channels. An off position can also be selected so that the input signal can be derived from another TDA8440. The circuit has two three-state switches for audio channels and one three-state switch for the video channel. There is a video amplifier with a selectable gain of one or two. Expansion up to seven devices is possible. Minimum crosstalk attenuation for video switching is 60 dB and total harmonic distortion for the audio channel is maximum 0,1 %. The 18-pin IC operates from a supply voltage of 10 to 13,2 V and requires a maximum unloaded supply current of 50 mA. The operating ambient temperature range is 0 to 75 °C.

CIRCLE 1

PHONE PERIPHERAL POWER SUPPLY PROVIDES FRESH APPLICATION POSSIBILITIES

We are introducing a completely new concept to line-powered electronic telephone sets in the form of an integrated circuit which provides a power supply for peripherals such as extended dialling and/or loudspeaking facilities. The TEA1080 improves the performance of electronic telephone sets by eliminating disturbances/distortion caused when peripherals are powered directly from the line. In addition the bipolar circuit allows the use of peripherals not suitable to be powered directly from the line, for example memories, displays and microcontrollers.

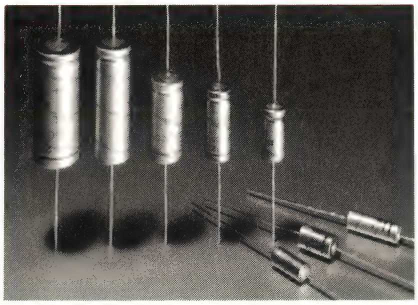


Operating over a line voltage range of 2,5 to 10 V, the new IC has a d.c. output voltage range of 2 to 9,5 V and a maximum d.c. output current of 30 mA. Since it has a high input impedance to audio frequencies of over 8 kΩ the TEA1080 can be connected directly to the telephone line (via a polarity guard). It offers two modes of operation: either a regulated output voltage or a constant d.c. voltage drop in series with a resistor between the line and its output terminal.

The circuit can handle large speech signals. For example, at a typical a.c. line level of 1,5 V imposed on a d.c. level of 4,5 V, the distortion of the line signal is less than 2 % for an output current of 15 mA.

The TEA1080 is powered by a part of the surplus of the line current which is normally sinked to the voltage regulator of the speech/transmission circuit. The circuit requires only five or six external capacitors and resistors. Maximum internal supply current is 1 mA and operating ambient temperature range is −25 to 70 °C. The TEA1080 comes in an 8-pin plastic DIL.

CIRCLE 2



SOLID ALUMINIUM ELECTROLYTICS COMPLEMENT EXISTING SERIES

Philips is complementing its existing 123-series of axial solid aluminium electrolytics with a new series offering enhanced CV-products in smaller can sizes. The new 125-series brings all the advantages of solid aluminium electrolytics to applications previously only covered by solid tantalum electrolytics. Advantages such as: no failure mechanism; wide operating temperature range from −55 to +125 °C; reverse voltage capabilities; high ripple current; and no requirement for a charge/discharge series limiting resistor.

The new series covers three can sizes: can size B (5 x 15 mm); can size A3 (6 x 10 mm); and can size A2 (5 x 10 mm). Can size B is identical in dimensions, CV-product and specifications to the CSR-13 (tantalum standard) can size B. Can size A3 is identical to can size B in CV-product and specifications; the feature of this type is its short length making it very suitable for automatic insertion. Can size A2 covers a lower CV-product range and is also ideal for automatic insertion.

The 123- and 125-series together now offer equivalents for all tantalum can sizes, as well as two larger sizes (can sizes 5 and 6).

Specified to the IEC384-4 long life grade, the new 125 capacitors offer long life and high reliability, for example endurance test lifetime at 125 °C is 2000 hours. Nominal capacitance range (E6 series) is 0,22 to 68 μF with a tolerance of 20 %. Rated voltage range is 4 to 35 V. Climatic category is 55/125/56.

CIRCLE 3

THE COMPLETE COMPONENT COMPANY

Philips Electronic Components and Materials Division, 5600 MD Eindhoven, The Netherlands

FASTEST PROMs ON THE MARKET STORE 16 TO 64 KBITS

We are supplying a new family of high-speed bipolar PROMs consisting of the 16 Kbit 82HS195/195A/195B, the 32 Kbit 82HS321/321A/321B and the 64 Kbit 82HS641/641A/641B. The 82HS195B, 82HS321B and 82HS641B are the fastest 16, 32 and 64 Kbit PROMs in the industry with maximum access times of just 25, 30 and 35 ns respectively.

The speed capability of the PROMs is a direct result of a new proprietary process technology known as HS2Z. This combines the best features of oxide isolation and vertical fuse integration. In addition to high speed, PROMs made with HS2Z demonstrate low power dissipation and very high field fusing yields. Applications for the TTL-compatible devices include high-speed electronic data processing, telecommunications, sequential control, microprogramming, control store, random logic and code conversion. The devices are field programmable using commercially available PROM programmers and have been tested to programming yields of better than 98 %.

The 20-pin N82HS195 (the N prefix indicates the commercial operating temperature range of 0 to 70 °C) has a maximum access time of 45 ns; the N82HS195A is rated at 35 ns maximum and the N82HS195B at 25 ns. The extended temperature version (prefix S; −55 to +125 °C) offers a maximum access time of 35 ns. Power dissipation is typically 35 μW per bit. These 16 Kbit PROMs are organized 4 K x 4 bits.

The 24-pin N82HS321, N82HS321A and N82HS321B have maximum access times of 45, 35 and 30 ns. Typical power dissipation is 20 μW per bit. Organization of these 32 Kbit devices is 4 K x 8 bits. Organized 8 K x 8 bits, the 24-pin N82HS641, N82HS641A and N82HS641B have maximum access times of 55, 45 and 35 ns and a typical power dissipation of 20 μW per bit.

All the PROMs have on-chip decoding and a chip-enable input for memory expansion. They need no separate fusing pins and feature three-state outputs for optimization of word expansion in bussed organizations. The PROMs are supplied with all outputs at a logic HIGH. They are available in ceramic or plastic DILs, and in plastic leaded-chip-carriers.

CIRCLE 4

WIDEBAND TRANSISTOR HAS HIGH POWER HANDLING CAPABILITY

Philips is expanding its line of wideband transistors with a new type possessing a transition frequency of typically 7,5 GHz and exhibiting the highest presently available power handling capability for this category of transistor. The BFG195 can handle a power dissipation of 0,5 W and features a unilateral power gain of 12 dB at an operating frequency of 2 GHz.

The BFG195 is for applications in high-gain wideband systems up to 2 GHz, for example in the first intermediate frequency section of satellite tv receivers.

The BFG195 incorporates Philips second wideband transistor crystal with a transition frequency of 7,5 GHz. The first in the range, the BFG65, is a lower power-rated type. The higher power handling capability of the BFG195 is due to a larger active area of the crystal almost three times the size of the BFG65 crystal. The improvement in power handling performance has been achieved without any increase in distortion.

The npn transistor is encapsulated in the plastic crosspack SOT-103. Maximum collector-emitter voltage is 10 V.

CIRCLE 5

STATE-OF-THE-ART 8-BIT MICROCONTROLLERS AVAILABLE NOW

As a true alternate source for Intel's 8051 family of 8-bit microcontrollers, we provide a reliable European source for the latest state-of-the-art versions of these industry-standard devices. New types include the MAB8052AH, MAB8032AH and a very fast 15 MHz version of the MAB8031AH. All these microcontrollers are manufactured in an advanced 2 micron NMOS process.

The MAB8052AH contains a non-volatile 8 Kbytes of ROM and 256 bytes of RAM, 32 I/O lines, and three 16-bit timer/event counters. External memory is expandable up to 128 Kbytes. The architecture features non-page orientated instructions, direct addressing, four 8-bit register banks, stack depth up to 256 Kbytes, and binary and BCD arithmetic plus bit handling capabilities.

The MAB8032AH is a ROMless version of the MAB8052AH. Both devices have a 12 MHz on-chip oscillator resulting in an execution speed of 1 μs for 58 % of the instructions. The instruction set consists of 255 instructions 44 % of which are one byte, 41 % two byte and 15 % three byte. With an external clock, frequency is variable from 3,5 to 12 MHz. Both the MAB8052AH

and MAB8032AH are packaged in a 40-lead plastic DIL. The devices will soon also be available in the 44-lead PLCC44 plastic leaded-chip-carrier.

The MAB8031AH is a ROMless version of the MAB8051AH. The new 15 MHz type is an addition to the existing 8, 10 and 12 MHz versions. The MAB8031AH features 128 bytes RAM, 32 I/O lines, and two 16-bit timer/event counters. The device is available in either a 40-lead plastic DIL or a 44-lead plastic leaded-chip-carrier.

For the MAB8031AH different versions are available covering the temperature ranges 0 to 70 °C, −40 to 85 °C, and −40 to 100 °C. This makes the device suitable for a wide variety of control applications under different environmental conditions.

CIRCLE 6

PHILIPS

Programming aids minimize errors during software design, coding, and modification

Chris Terry, *Associate Editor*

You can't yet find a computer that programs itself—such things exist only in the realm of science fiction—but by employing one or more programming aids, you can make your computer handle much of the tedious work associated with program or software-system design. These programming aids—which include structured-analysis tools, syntax editors, language-sensitive editors, interpreters, formatters, profilers, and source-code managers—check large quantities of data rapidly for internal consistency, adherence to syntactical rules, and correlations between data sets. Such checks minimize the errors that can occur during program or software-system design, during coding, and during program modification.

Computerized system analysis

When you're designing a program or software system, you'll find structured-analysis tools invaluable. The structured-analysis technique, which was originally developed by Yourdon Associates (now Yourdon Inc) of New York, uses data-flow diagrams (DFDs) to describe a proposed software system. DFDs define each item of data used as input to a transformation process, the data transformations that take place, and the data items that emerge from the process.

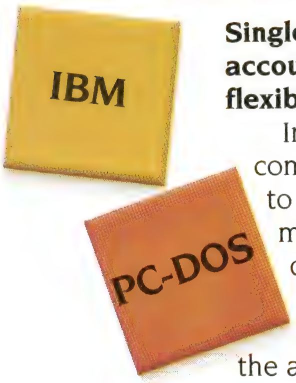
DFDs are simple and clear enough to allow your customer to understand precisely what a program will do, so that you and the customer can readily agree on the software system's specifications. The DFD's process symbols represent complex tasks or even whole programs. When the analyst and programming team begin to build the system from the top down, they expand the DFD's process symbols at each level, splitting complex tasks into simpler tasks or even new DFDs.

For your entire software system to be internally consistent, you must build a data dictionary as your design proceeds from level to level. The entries in the data dictionary completely define all input data items, all intermediate products, and all output data items. Programmers working on different parts of the system refer to the data dictionary to ensure that they don't give different names to the same data item.

Although structured analysis is invaluable in creating new systems, it entailed a lot of clerical overhead until recently. Although you could easily build and update the data dictionary with a word processor—or even create DFDs with a graphics package—you couldn't integrate the data dictionary with the DFDs in the computer. Your project depended, therefore, on the frequent manual updating of the dictionary and the DFDs, and the circulation of this information, on paper, to the programming team.

You can develop data-flow diagrams (DFDs) *for a complex software system with the aid of Tektronix's structured-analysis tools for VAX/VMS and Unix systems. You specify data items with the graphics editor, and the software automatically places the items in the project's data dictionary.*

THE INTEGRATED SOLUTION FOR MICROPROCESSOR DEVELOPMENT/DEBUG



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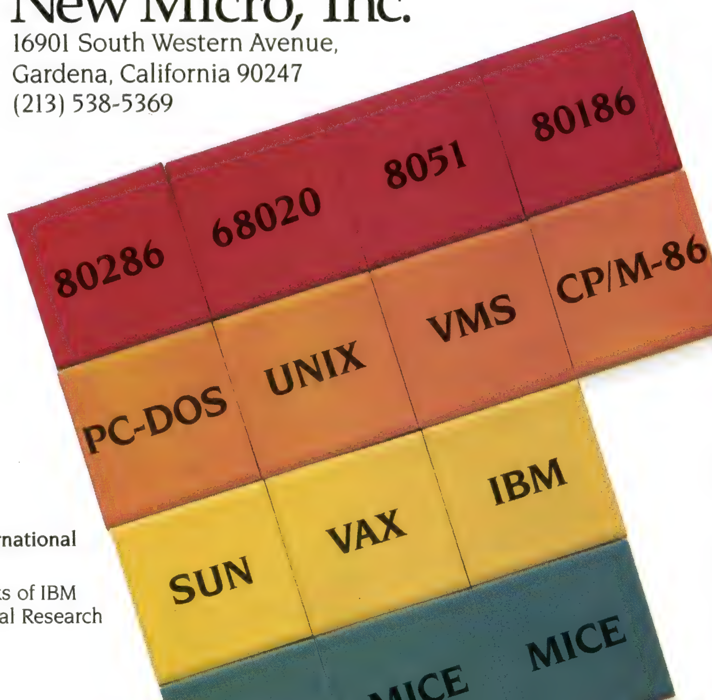

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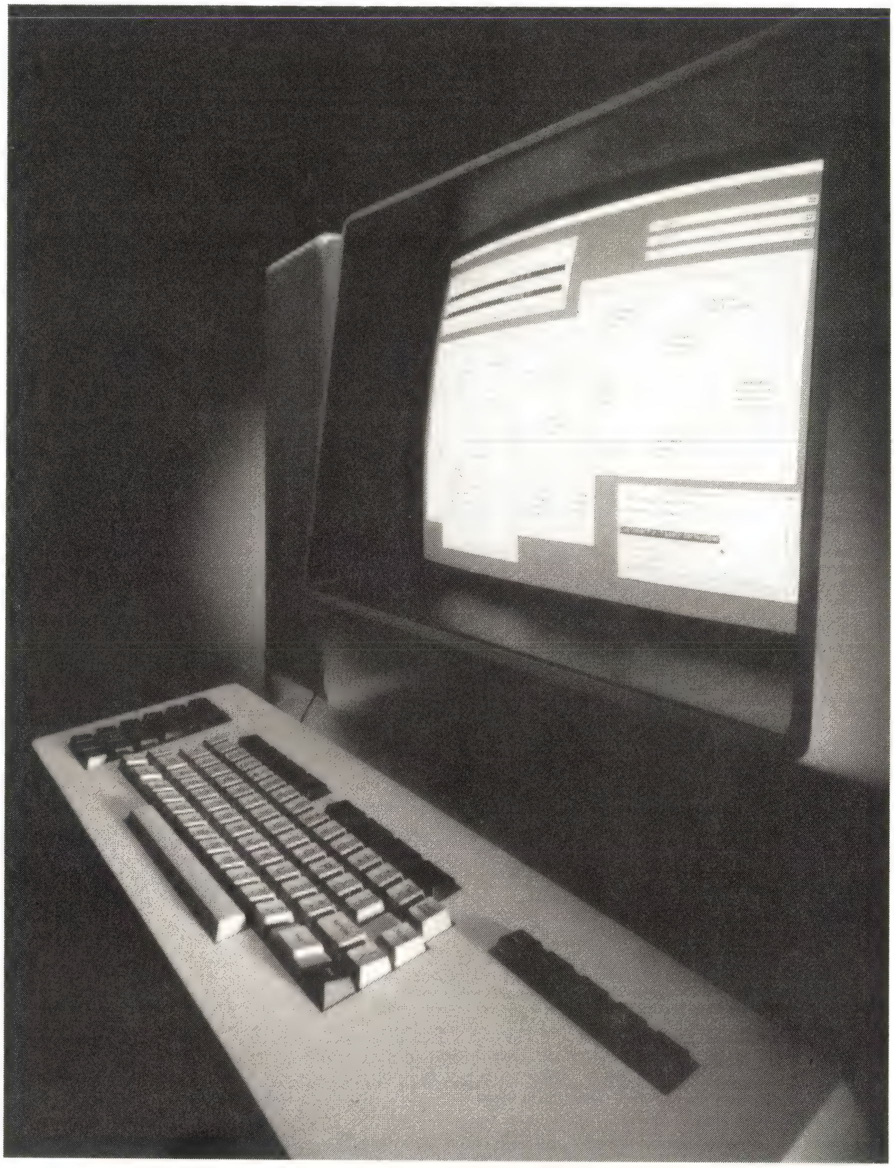
CIRCLE NO 176

A number of new programming tools, however, let you integrate the DFD with the data dictionary and perform all updating on the computer. One such tool, Analyst Toolkit from Yourdon Software Engineering (a joint venture of Yourdon Inc and the Cadware Group Ltd of New Haven, CT), runs on the IBM PC, PC/XT, PC/AT, and compatibles. The software package's graphics allow you to create symbolic graphic models of real-time, on-line, and batch-processing systems, as well as other types of systems.

You use a mouse to draw DFDs, entity-relation diagrams, state-transition diagrams, and free-form graphics. You build the data dictionary from your diagrams by means of the diagram-extraction feature. Error-checking facilities test the graphics models at all stages of the design for consistency and accuracy. The Analyst Toolkit requires 640k bytes of RAM and 10M bytes of hard-disk storage; it costs $3500.

Tektronix offers structured-anaylsis editors that run on DEC VAX computers under Unix or VMS. These graphics editors let you build and display DFDs by extracting existing data items from the data dictionary. When you introduce new data items into a DFD, the editor prompts you for their definitions, checks them for consistency, and then automatically incorporates them into the data dictionary. Prices for the software start at $16,500.

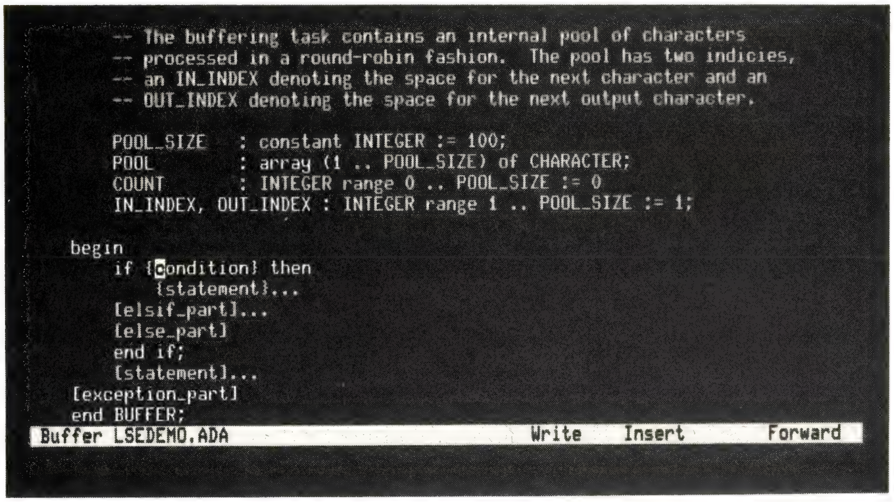


You can integrate all phases of software design, *from system analysis to coding and maintenance, by using Teamwork/SA from Cadre Technologies Inc. The package's language-sensitive editors provide templates and on-line help for C, Pascal, and Ada programmers.*

Another set of structured-analysis tools, Teamwork/SA from Cadre Technologies, runs on Domain workstations from Apollo (Chelmsford, MA). Both single- and multiple-user packages are available. The multiuser version lets all members of a design team access a central project library that includes data dictionaries, DFDs, process specifications, and project-management data. In addition, team members can enter annotations consisting of information necessary to the system model that doesn't fit into the standard structured model. Such annotations can consist of free-form text, and you can cross-reference them to many portions of the structured specification.

Teamwork/SA provides a graphics editor, a process-specification editor, analysis utilities, and a consistency checker. The graphics editor is syntax oriented and operates strictly according to Yourdon Associates' rules for building DFDs and for establishing their relationships to other objects in the system specifications. The process-specification editor also adheres to these rules. The package's analysis utilities can manipulate objects in the system only according to these rules, and its consistency checker detects both specification errors within a given DFD and inconsistencies between DFDs. Teamwork/SA costs $8900 per workstation.

An even more extensive system, Promod from Promod Inc, supports all stages of your software-system design, from structured analysis through coding and maintenance. The software operates on DEC VAX systems and on all IBM PC configurations. The project library inte-



Language-sensitive editors keep you from making syntax errors. *This editor, DEC's LSE, also shows you the names and data types of variables you've declared in the module you're working on.*

grates the data dictionary, DFDs, and minispecs during the structured-analysis phase of development. Promod also provides code-frame generators for C, Pascal, and Ada for use during the coding phase. These frames let you view the variables and data types that you've declared and entered in the data dictionary, ensuring that the code is syntactically correct and the variables are consistent.

The package also provides a comprehensive documentation facility, which takes the relationships between modules into account, and a version-maintenance facility, which ensures that when you rebuild your system after modifying it you use only the latest version of each module. Prices start at $9950 for the IBM PC version and $37,500 for the VAX-11/780 version.

Find errors while coding

Once your system analysis and design are complete, you can use another set of programming aids—syntax checkers, language-sensitive editors, interactive interpreters, formatters, and profilers—to ease your coding task. You don't need as much computing power to reduce coding errors as you do to automate system analysis, so you can usually use these tools on a personal computer.

If you use a syntax checker, you must first write the code with a standard editor. One example of a syntax checker is the Unix Lint utility, which comes in several versions for the MS-DOS environment. For example, Gimpel Software offers PC-Lint for $98. Entelekon offers a Lint package for $129.95.

Language-sensitive editors

Unlike syntax checkers, which check code after you've entered it, language-sensitive (or syntax-directed) editors operate according to the rules of one or more high-level languages (eg, Fortran, C, Pascal), detecting or correcting illegal statements as you enter them. HyperMicro Inc offers ESP, a syntax-directed editor that comes in versions for C and Pascal. The editor, which costs $200, recognizes the rules of the language and detects errors in the statements you enter. For example, the moment you enter the word "if" on a line, the editor displays a template showing the correct format of the If . . . Then . . . Else construction, with place holders that you can overwrite with your statements.

The software handles the tedious syntactic details automatically, without your intervention. For example, it inserts a semicolon at the end of each statement, pairs Begin and End statements (in Pascal) or braces (in C), and checks syntax, ensuring, for example, that you've declared variables properly and haven't mismatched data types. To use this program as a standard multiwindow text editor, you simply turn off the language-sensitive features and use just the general features, such as the global-search-and-replace and cut-and-paste functions.

Spruce Technology offers a similar syntax-directed editor for C programmers. The package, FirsTime, has macro capabilities, so you can generate whole program and statement structures on the screen with a single keystroke. It costs $295.

Some expert C programmers have found that, at least in the early versions, these packages reject some constructs that a Unix compiler would accept and handle correctly. Nevertheless, both packages are valuable aids to programmers who are not yet expert in C and Pascal or who want to avoid some of the syntactic detail so they can concentrate on the program logic.

C Ware Corp offers See, a general-purpose, full-screen editor that can edit two files simultaneously. The editor, which costs $50, has macro capabilities. It provides automatic indentation and matching of parentheses, brackets, and braces. The matching feature ensures that your program's structure is correct while giving you more freedom than do the mandatory templates and syntax checking of ESP and FirsTime.

Alice, a Pascal package distributed in the US by Software Channels Inc, combines a fill-in-the-blanks editor and syntax checker with an interpreter and extensive on-line help files. When you write a program or module with the editor, you can execute it immediately with the interpreter, either at full speed or one statement or one procedure at a time. A backward-tracing feature lets you find out just how the program reached a particular state-

ment. The package, which provides a number of other debugging features, costs $95.

One drawback of Alice is that it stores source code as a binary, tokenized file, so it doesn't let you use existing source-code files without rekeying them via Alice's editor. Turbo-Pascal source-code is an exception, however: A utility that comes with Alice can convert Turbo-Pascal source-code files to Alice's format. The utility performs syntax-checking on your code during conversion. Another drawback is that Alice is based on Waterloo Pascal, so its extensions may not correspond to those your compiler supports.

Language-sensitive editors that run on IBM PCs and compatibles are limited to some degree, both by the PCs' computing power and by the fact that the editors are chiefly for novices and programmers who work in the PC-DOS environment. However, for the professional programmer who works in a VAX environment under VMS or Unix, vendors offer a number of very sophisticated language-sensitive editors.

Language-sensitive editors for the VAX include Digital Equipment Corp's LSE, which provides both templates and on-line help for the Ada, Basic, Bliss, C, Cobol, Fortran, Pascal, and PL/I languages. The LSE is part of the company's VAXset package, which includes maintenance software and test facilities and starts at $13,800 for the MicroVAX. You can choose the fill-in-the-blanks mode, in which you complete statements such as "If . . . Then" statements. Optional statements, such as "Else" and "Else if," will disappear if you don't use them. Alternatively, you can enter your code in free form but call up help screens for any constructs about which you are in doubt. If you're writing an Ada program, for example, you can call up and view the data types and variables that you've declared, to make sure they're consistent.

The LSE can compile your program for error checking only (not for code generation) from within the editor. Compilation errors appear in one window, and the source code that caused the errors appears in a second window. You can immediately correct the error and continue the compilation. When you reach the end of the program, you can compile for code generation and link the modules.

A syntax-directed editor for Pascal programs in VAX or PDP-11 environments is the $1250 Pasced package from Real Time Products. Like Alice, Pasced stores programs in binary, tokenized form that represents their internal tree structure. However, Pasced lets you view external source-code files on a read-only basis, and you can import all or part of an external file by using a conversion utility, which checks the syntax of imported code during the conversion process.

Interpreters debug quickly

Another programming tool that can save you a lot of work on compiled programs is an interactive interpreter, which executes a module or a program and finds both syntax and logic errors before you compile and link the program.

Although compiled programs run very quickly, corrections to them require a lot of work. You write your program with a standard editor, then leave the editor and invoke the compiler, which tries to process the whole program, generating executable code unless it encounters a drastic error. When the compilation is complete, you must inspect and record the list of errors, return to the editor to make the corrections, and reinvoke the compiler. When the compiler finds no more errors, you have to invoke the linker before you can run the program. Any change to the program, no matter how small, requires you to repeat the entire edit-compile-link-run cycle.

Interactive interpreters, however, let you correct errors before you compile code. Vendors are offering an increasing number of interpreters for C and Pascal. In the personal-computer environment, where C and Pascal compilers differ considerably from each other as well as from the corresponding Unix or VMS compilers, each interpreter operates in conjunction with a specific MS-DOS compiler. For example, Gimpel Software supplies C-terp in five different versions that work in conjunction with the Lattice (Glen Ellyn, IL), Computer Innovations (Tinton Falls, NJ), Aztec (from Manx Software Systems), Mark Williams (Chicago, IL), and Microsoft (Redmond, WA) 3.0+ C compilers. C-terp costs $300.

MS-DOS users can choose from at least six other C interpreters ranging in price from $49 for Apprentice C (from Manx Software Systems) to $500 for Smart C (from AGS Computers). The Smart C package includes a migrator program that translates any C source file in ASCII format into a form that Smart C can use both to edit and to interpret. Further, once the editor has checked the program for syntax errors and the interpreter has successfully run the program, you can create a clean source-code file in ASCII format. The company claims that such an output file will be compatible with most commercially available compilers and will compile cleanly without modification.

C interpreters are also available for minicomputer or workstation environments. Smart C, for example, comes in versions for the AT&T 3B series and for VAX systems running Unix System V, Berkeley BSD 4.2, or Xenix. The VAX 11/780 version costs $10,000.

Catalytix's Safe C, a package that contains a stand-alone interpreter as well as a number of analytical utilities, runs on a number of computers under a variety of operating systems, including MS-DOS, VAX/VMS, and Unix. It costs from $1000

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to $8000, depending on the operating system you buy it for. This interpreter implements an abstract machine for C, so the debugged source code will compile cleanly on any other machine. The interpreter has a number of debugging features: It can perform single-stepping, in which the interpreter stops at each semicolon; it can set breakpoints at any point in the source code, so they can depend upon any group of conditions; and it can trace at every expression, statement, and function call.

If you don't use a language-sensitive editor or an interpreter while coding, but simply use a standard editor to write source code for your compiler, you can easily miss a closing parenthesis or brace, or change the indentation level by mistake. Formatters and profilers help you avoid such errors. Formatters let you arrange lines of code so they're easy to read. Profilers provide statistics on how many times each procedure or function is called.

Source Print from Aldebaran Laboratories Inc, a formatter for the MS-DOS environment, formats your C, Pascal, or Modula-2 source code by emphasizing reserved words, indenting nested structures, and placing vertical lines between paired braces or Begin . . . End pairs to show the level of nesting. The program also prints statistics on the number of characters and lines in the file. You can choose to have the program number each line of the program. Source Print sells for $97.

Catalytix offers a dynamic profiler for use with the company's Safe C interpreter. The profiler, which

For more information . . .

For more information on the programming aids described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following vendors directly.

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costs from $1000 to $8000, depending on the operating system, produces both statement- and function-level statistics. It indicates how many times each statement or function was executed. The software prints the statement-level statistics alongside the statements to which they refer, and it presents the function-level profile in the form of a histogram. The statistics this program provides are useful both for finding sections of code that don't get executed and for identifying potential bottlenecks.

When you modify your completed system, you must make sure that your next release contains the latest versions of every module. If you're working under Unix, you can use the Make utility, which analyzes the intermodule dependencies of a software system. When you change one module and recompile it, the Make utility constructs a command file containing all the commands you need to change, recompile, and relink all the modules affected by the change. Of course, you have to set up the dependencies in the first place, but a command language associated with the Make utility allows you to do so relatively easily.

The Make utility is part of the Unix environment and comes with that operating system, but if you're working in an MS-DOS environment, you can use one of several add-on versions of the utility. Softfocus offers a Make utility for $59 that works with programs written in any high-level language. Seidl Computer Engineering offers SMK, another version of the utility, for $100. SMK works in conjunction with Seidl's SVM ($300), a version manager that maintains a complete revision history of any text or source-code file. The manager ensures that when you rebuild your software system, either to upgrade it or reconfigure it for different hardware, you link in the correct versions of the required modules. You can purchase both SVM and SMK for $380.

An even more extensive version-maintenance system from DEC consists of two programs: the code-management system (CMS), and the module-management system (MMS), which are part of the VAXset package. The CMS automatically records every change to all of a project's source-code files, the dates of the changes, and the names of the programmers who made the changes. CMS merges modifications and stores current and historic versions of all source-code files in a library. The program, which is similar in function to the Unix SCCS (source-code control system), allows you to reconstruct any phase of a project.

The MMS follows instructions and rules in a system-description file in which you've described the interrelationships of the various components of your software system and defined the module dependencies. When you rebuild your system, MMS determines which modules of the system have changed since the last release and need to be recompiled. The software then makes sure that the rebuilt system incorporates all the latest changes.

The design, coding, and system-maintenance tools that are rapidly becoming available for personal computers, workstations, and minicomputers, are beginning to do for software engineers what CAE systems do for electronic-hardware designers. By lifting much of the clerical burden, these tools leave the engineer free to concentrate on the aspects of design that require imagination and intelligence. Although software-design and coding tools are not yet complete expert systems, you can expect to see software vendors applying some of the emerging artificial-intelligence techniques to design, coding, and maintenance tools in the near future. **EDN**

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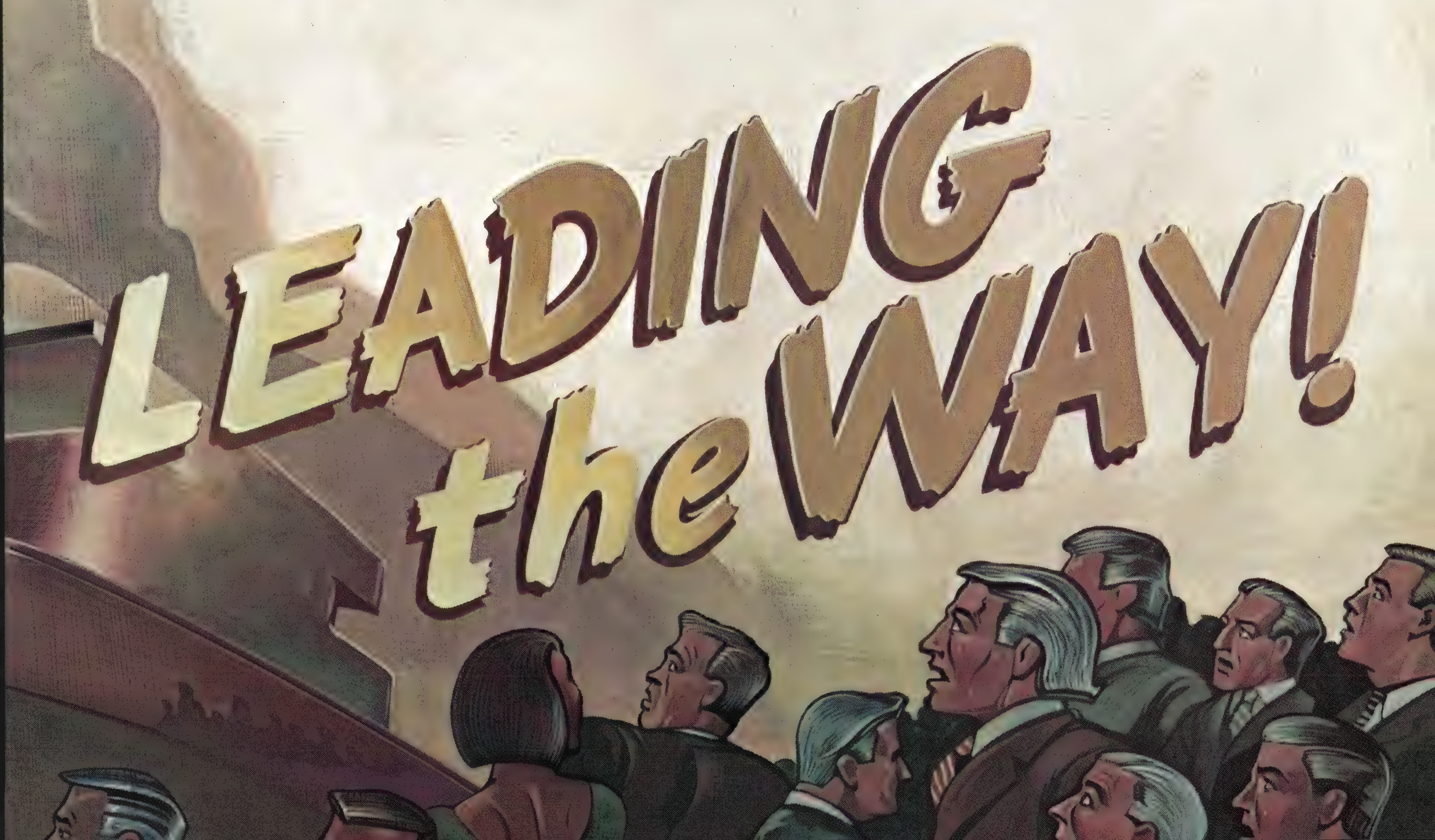

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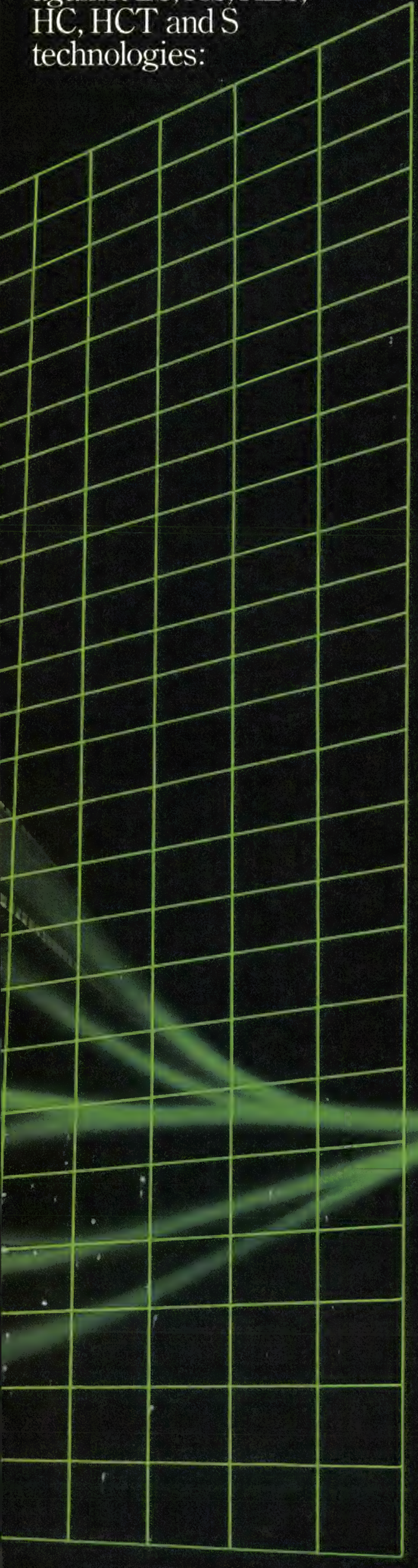

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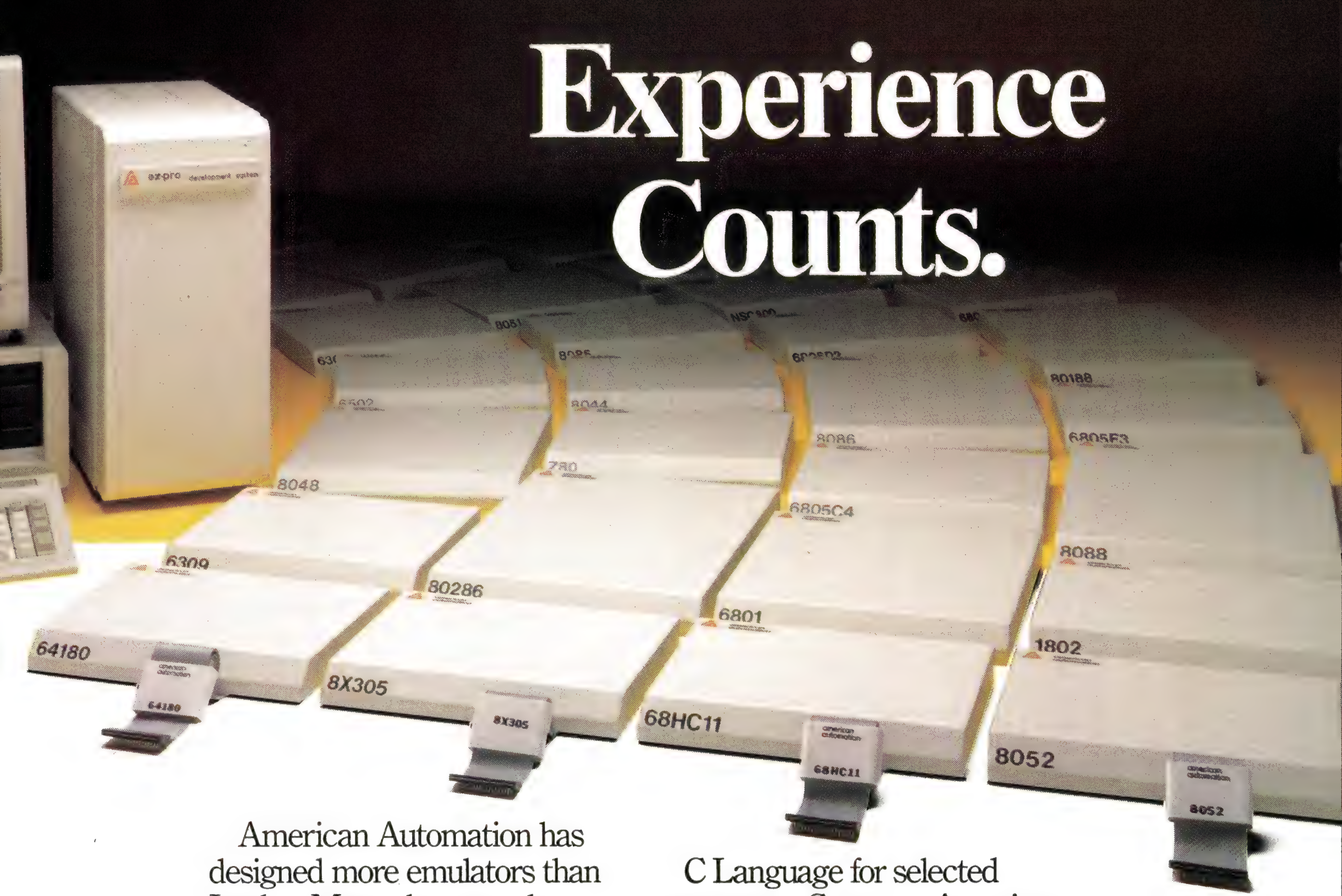

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Varied Electro/86 program will emphasize IC- and system-design topics

Joanne Clay, *Staff Editor*

Sessions on IC and system design will highlight the Electro/86 conference, which will cover a wide variety of technical subjects. The conference, which will be held from May 13 through 15, 1986, at the Bayside Exposition Center and World Trade Center in Boston, MA, will include talks on the latest developments in semicustom ICs, ASICs, logic arrays, VLSI circuits, memory technology, fault simulation, packaging methods, interconnect technology, and other subjects.

Engineers interested in IC design will want to attend the discussions on application-specific ICs. As participants in **session 4** will report, IC manufacturers are making many of the standard VLSI functions available as macrocells for their standard-cell libraries. By incorporating these macrocells in semicustom ICs along with random logic, manufacturers can now actually build a system on a chip.

ASICs are becoming increasingly important for OEMs who wish to create competitive systems, as speakers in **session 7** will point out. They'll discuss how OEMs can maximize the benefits of ASICs by understanding the choices they must make in system design, ASIC product selection, CAE design tools, and vendor interfaces.

Individuals interested in semicustom-IC design will also want to attend **session 1,** which will focus on choosing design centers for custom- and semicustom-IC design. Lecturers at this session will explore the differences between manufacturer, distributor, and independent design centers. They'll also consider the tradeoffs—including multiple sourcing, technology sources, speed, power, turnaround time, and cost—involved in choosing a design center or doing designs in house.

The ever increasing complexity of LSI/VLSI designs is making fault

ELECTRO/86 PROFESSIONAL PROGRAM
BAYSIDE EXPOSITION CENTER BOSTON, MA

		ROOM A	ROOM B	ROOM C
TUESDAY MAY 13	9:00 AM TO 11:00 AM	1 CHOOSING A DESIGN CENTER FOR YOUR CUSTOM/SEMICUSTOM SYSTEM DESIGN	2 THE STRATEGIC DEFENSE INITIATIVE IN PERSPECTIVE	3 PERSPECTIVES ON SURFACE MOUNTING IN THE UNITED STATES
	12:30 PM TO 2:30 PM	4 ADDING VLSI FUNCTIONS TO STANDARD CELL LIBRARIES FOR APPLICATION-SPECIFIC IC DESIGN	5 ENGINEERING EDUCATION—WHAT'S WRONG, AND WHAT NEEDS TO BE DONE TO CORRECT IT?	6 HIGH-PERFORMANCE INTERCONNECT TECHNOLOGY: TAPE AUTOMATED BONDING (TAB)
	3:30 PM TO 5:30 PM	7 ASIC: CHOICES FOR A NEW GENERATION	8 SIGNAL-FLOW ANALYSIS*	9 SURFACE MOUNTING WITH INTEGRATED CIRCUITS
	9:00 AM TO 11:00 AM	10 RECENT ADVANCES IN DISCRETE MOS-GATED POWER STRUCTURES	11 VLSI DESIGN WITH SILICON COMPILERS	12 BEYOND MEMORY—DIVERSE APPLICATIONS OF ELECTRICALLY ERASABLE MEMORY TECHNOLOGY
WEDNESDAY MAY 14	12:30 PM TO 2:30 PM	13 POWER-IC AND SMART-POWER-IC TECHNOLOGY	14 AN OVERVIEW OF OFFSHORE OPPORTUNITIES FROM FOUR WORLD AREAS	15 THE FASTEST SILICON TODAY—BIPOLAR ECL
	3:30 PM TO 5:30 PM	16 HOW BRUSHLESS DC MOTORS ARE COMING OF AGE IN THE WORLD TODAY	17 GOING PUBLIC	18 RECENT DEVELOPMENTS IN LOGIC-ARRAY TECHNOLOGY
	9:00 AM TO 11:00 AM	19 GROUNDING AND SHIELDING ELECTRONIC INSTRUMENTATION*	20 COMMUNICATION FUNDAMENTALS IN FLEXIBLE AUTOMATION*	21 SYSTEM IMPLICATIONS AND APPLICATIONS RESULTING FROM RECENT DISK-CONTROLLER-IC TECHNOLOGY ADVANCES
THURSDAY MAY 15	12:30 PM TO 2:30 PM	22 THE WHYS AND WHEREFORES OF THE TRANSFER OF TECHNOLOGY	23 THE NEXT GENERATION OF PROGRAMMABLE LOGIC DEVICES WILL LAUNCH A NEW ERA IN SYSTEM DESIGN—I	24 FAULT-SIMULATION TECHNIQUES AND TESTABILITY ANALYSIS
	3:30 PM TO 5:30 PM	25 RADAR—LATEST DEVELOPMENTS AND FUTURE TRENDS*	26 THE NEXT GENERATION OF PROGRAMMABLE LOGIC DEVICES WILL LAUNCH A NEW ERA IN SYSTEM DESIGN—II	27 NONSTANDARD ATMOSPHERIC EFFECTS ON RADAR- AND COMMUNICATION-SYSTEMS PERFORMANCE

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simulation and testability analysis more and more important. Participants in **session 24** will investigate and redefine the problem of testability analysis by presenting appropriate fault models for these VLSI circuits. The speakers will discuss the various solutions presented by leading researchers in the field and will evaluate the solutions from a user's perspective.

The next generation of programmable-logic devices (PLDs) will be the topic of **sessions 23** and **26,** which will run in series. Speakers at these sessions will discuss the architecture of the new devices and investigate advanced software tools and new design techniques for PLDs.

The use of monolithic ICs to replace discrete circuits and logic in driving high-voltage or high-current resistors, capacitors, and inductive loads will be covered in **session 13.** Participants will discuss these monolithic-IC technologies and delineate the strengths of each in terms of their benefits for the user and their parametric performance.

Also related to IC design is **session 9,** which will investigate surface mounting with ICs. Session participants will cover relevant issues in surface-mount technology, such as packaging trends, standardization, electrical characteristics, the reliability of components and assemblies, computer-aided design, and automatic placement. **Session 3** will also look into surface mounting. It will present perspectives and trends in the US from the viewpoints of a professional forecaster, a successful user of the technology, a passive-component supplier, and a supplier of active components.

The presentations related to system design include **session 12,** which will investigate applications of electrically erasable memory technology in nonmemory products. **Session 15** will review the bipolar ECL devices currently available to the system designer, and **session 21** will consider the system implications and applications of recent advancements in disk-controller ICs. Speakers at this session include disk-controller-IC users, who will indicate how system designers can use the technological changes in

Mini/Micro Northeast-86

Sessions on data communications and microprocessors will predominate at Mini/Micro Northeast-86, a conference that targets system designers. The conference, which offered only nine sessions last year, will include 27 sessions this year and will take place concurrently with Electro at the World Trade Center in Boston, MA. Like Electro, Mini/Micro Northeast will feature four minitutorials, which will provide basic information in subjects that may be outside the area of specialization of many engineers.

Among the data-communication topics the program will cover is satellite data communication, the subject of **session 4,** a minitutorial that will present the current technology for data communications utilizing micro Earth stations. **Session 13** will focus on the current status of and new uses for fiber-optic systems in applications other than telecommunications. Participants in this session will report on fiber/cable status and describe applications of fiber-optic systems in data links and local-area networks (LANs).

For registrants who wish a general understanding of the theory, problems, and opportunities of the proposed Integrated Services Digital Network (ISDN), **session 1** will give an overview of ISDN architecture, standards, implementation, and services. The session, which will be presented from the point of view of a provider of ISDN services, will predict the future direction of the ISDN.

Session 10 will also touch on the ISDN. Speakers in this session will explore the industry's progress toward implementing communications standards that will allow today's office automation systems to integrate LAN, PBX, and ISDN services in a user-friendly and cost-effective manner.

Sessions on microprocessors will include talks on 32-bit high-end microprocessors, the topic of **session 15.** Lecturers at this session will examine the options available to system designers who are considering different types of core processors for their systems. Speakers will discuss 32-bit, reconfigurable, and RISC devices. **Session 12** will concentrate on the bus options available to the user of these high-level computer architectures.

Other microprocessor topics to be covered at Mini/Micro Northeast will include a discussion, in **session 18,** of programmable, single-chip digital signal processors (DSPs). Participants will give information on specific DSP products. In addition, **session 27** will probe new applications for low-cost microcontrollers, and **session 19** will investigate various methods of generating software for μPs. Speakers will consider evaluation boards, emulators, computer generation, and high-level-language compilers.

Bit-slice microprocessors will be the subject of **session 3,** which will focus on new concepts in CMOS bit-slice μPs and provide design information and examples of applications for these innovative μPs. Concentrating on high-end systems that use bit-slice processors, **session 6** will present informa-

these ICs to their best advantage.

Finally, **session 18** will survey recent developments in logic-array technology, presenting the design choices available to engineers who are creating new systems. Other technical sessions in Electro's varied program will include discussions of interconnect technology, fault simulation, signal-flow analysis, and discrete MOS-gated transistors.

To explore technical areas outside your particular field, you may want to attend one or more of the minitutorial sessions at Electro/86. Engineers will have the opportunity to acquaint themselves with four technical fields in minitutorial **sessions 8, 19, 20** and **25**, which will be free of charge to conference registrants.

Session 8, on signal-flow analysis, will review the classical theory of signal-flow graphs. At this session, Ronald E Scott of Northeastern University will introduce the basic concepts of signal-flow analysis, describe the algebra for reducing them, and examine the derivation of Mason's general reduction formula. Scott will concentrate on presenting practical applications to solving problems in transistor circuits, op-amp circuits, servomechanisms, and electromechanical circuits.

Session 19 will cover the principles involved in typical grounding and shielding problems. Bruce Wedlock of Lowell Institute School (Cambridge, MA) will explain grounding and shielding techniques that replace the trial-and-error method with sound, systematic methods of shielding. This introductory-level tutorial will target electronic-circuit designers. Scheduled for the same time slot is **session 20,** which will focus on the fundamentals of machine-to-machine communication. Session chairman Robert E Parkin and four other speakers will analyze such subjects as robotic movement and path planning, sensors, vision, and the implementation of flexible automation.

The final Electro minitutorial, **session 25,** will review the latest advancements—and predict future trends—in radar-system technology. Eli Brookner of Raytheon Co (Wayland, MA) will discuss monolithic microwave integrated circuitry (MMIC), ultralow-sidelobe antennas, synthetic aperture radar,

tion on a variety of applications from the systems-level approach to the design process.

In addition to sessions on data communication and µPs, Mini/Micro will offer sessions on a number of other subjects, including computer-aided design, personal computers, telecommunications, process control, LSI devices, product standards, engineering management, automated testing, real-time systems, static RAMs, smart cards, Unix, and software design.

MINI/MICRO NORTHEAST-86 PROFESSIONAL PROGRAM
WORLD TRADE CENTER, BOSTON, MA

		ROOM A1	ROOM A2	ROOM A3
TUESDAY MAY 13	9:00 AM TO 11:00 AM	1 INTEGRATED SERVICES DIGITAL NETWORKS*	2 MICRO-TO-MAINFRAME COMPUTER-AIDED DESIGN	3 THE CMOS REVOLUTION HITS BIT-SLICE MICROPROCESSORS
	12:30 PM TO 2:30 PM	4 SATELLITE DATA COMMUNICATION*	5 USING THE PC FOR LOGIC DESIGN	6 ADVANCED APPLICATIONS USING NEW-GENERATION BIT-SLICE PROCESSORS
	3:30 PM TO 5:30 PM	7 TELECOMMUNICATIONS: INTERFACING TO THE NETWORK	8 ENHANCING YOUR PC ENGINEERING WORKSTATIONS	9 DESKTOP COMPUTERS IN PROCESS CONTROL*
WEDNESDAY MAY 14	9:00 AM TO 11:00 AM	10 INTEGRATING ISDN AND LAN SERVICES IN THE OFFICE ENVIRONMENT	11 PRODUCT STANDARDS: A GROWING CONCERN*	12 BUS WARS—THE 32-BIT FRONTIER
	12:30 PM TO 2:30 PM	13 OPTICAL COMMUNICATION	14 SMARTER CHIPS FOR BETTER DESIGN	15 32-BIT HIGH-END MICROPROCESSORS
	3:30 PM TO 5:30 PM	16 ENGINEERING MANAGEMENT TECHNIQUES FOR THE FUTURE	17 NONIMPACT PRINTING FOR INSTRUMENTATION, SCIENTIFIC, AND ENGINEERING APPLICATIONS	18 PROGRAMMABLE SINGLE-CHIP DIGITAL SIGNAL PROCESSORS
THURSDAY MAY 15	9:00 AM TO 11:00 AM	19 ALTERNATIVE METHODS FOR MICROPROCESSOR SOFTWARE GENERATION	20 PC-BASED CAE—IS IT THE TOTAL SOLUTION?	21 TOOLS FOR MIL-STD-1758A SOFTWARE DEVELOPMENT
	12:30 PM TO 2:30 PM	22 SOFTWARE DESIGN TOOLS FOR REAL-TIME SYSTEMS	23 COMPUTER-INTEGRATED TEST—CLOSING THE QUALITY FEEDBACK LOOP	24 FUTURE TECHNOLOGY OF SMART CARDS IS AVAILABLE TODAY
	3:30 PM TO 5:30 PM	25 USING UNIX IN A REAL-TIME ENVIRONMENT	26 SYSTEM AND APPLICATION IMPLICATIONS FROM FAST STATIC-RAM ADVANCES	27 NEW APPLICATIONS FOR LOW-COST MICROCONTROLLERS

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adaptive array processing, the impact of VLSI circuits and VHSICs (very-high-speed ICs) on digital radar signals and data processors, systolic-array signal processors, silicon compilers, and residue arithmetic. Instead of giving detailed mathematics and derivations, the session will summarize key points of the technology.

Electro/86 registrants will also have the opportunity to explore some nontechnical subjects of interest to engineers. These five sessions will include discussions of various business, educational, and legal topics. For example, participants in **session 2** will undertake a comprehensive critical analysis of the President's Strategic Defense Initiative (SDI) proposal from technical, legal, computational, and political points of view.

Speakers in **session 5** will consider the growing mismatch between engineering education and proper preparation for engineering practice. The discussion will focus on identifying current inadequacies and misconceptions in engineering education and recommending measures the engineering community can take to correct the problems.

Discussions in **session 14** will investigate opportunities for electronics firms to cut costs by manufacturing their products offshore. The session's four papers will inform the audience about specific opportunities in four offshore areas—the Eastern Caribbean, Mexico, Hong Kong, and Scotland.

Session 22 will deal with the purchase and sale of privately developed technology and with obtaining US government-developed technology. Participants in this session will also address the issues of intellectual-property rights, commercial contracts, the law of sales, and making transactions that are beneficial to both parties. Finally, **session 17** will present a discussion of the advantages and disadvantages a company faces in undertaking an initial public offering of its stock.

The professional sessions represent only some of the events scheduled for Electro/86. The conference will also offer special tutorials, a keynote breakfast, a marketing conference, and a film program.

Registrants can choose from four tutorials, which they can attend for a fee. The tutorial entitled "Topics on the strategic defense initiative" will explore the engineering problems associated with the SDI. "Personal-computer-based artificial intelligence/expert systems" will focus on tools for the effective, easy application of AI techniques by end users for solving nontraditional problems on 16-bit personal computers, especially the IBM PC. In the two remaining tutorials, industry experts will consider whether silicon compilers will render gate arrays obsolete and will explore new applications for LANs in business, industry, and science.

This year's keynote speech will focus on communications, which is the conference's theme. At the keynote breakfast, Robert Allen, chairman and CEO of AT&T Information Systems, will speak on "Integration and cooperation: The key to success in the information age." Allen will describe strategy and direction for his company as well as for the office-automation industry as a whole.

Another special event scheduled for Electro is a marketing conference entitled "Will electronics be the next shoe/textile industry?" At the conference, a 5-member panel will examine the trends in the electronics industry that are causing local companies to buy components and subsystems directly from offshore companies. The panel will also consider the effect of this trend on distributors and representatives, many of whom are being left out of the sales chain in such transactions. The panelists, who represent different viewpoints, will read brief statements and then answer questions from the audience. **EDN**

Electro schedule and registration information

Electro/86 will take place Tuesday May 13 to Thursday May 15, 1986, in the Bayside Exposition Center, Boston, MA. Mini/Micro Northeast will take place at the same time in Boston's World Trade Center.

More than 1200 exhibits will be on display from 10 AM to 6 PM on Tuesday and Wednesday and from 10 AM to 5 PM on Thursday. Electro exhibits will be in both buildings; all Mini/Micro exhibits will be at the World Trade Center.

Complimentary-registration forms for Electro and Mini/Micro Northeast are available through any of the exhibiting companies and from many local engineers and manufacturers' representatives. Complimentary-registration forms must be received by April 25, 1986. Registration at the door for the conferences is $10 for IEEE members, $20 for nonmembers.

Fees for Electro tutorials range from $160 to $190 for IEEE or ERA (Electronic Representatives Association) members and from $200 to $230 for nonmembers. Tickets to Tuesday's marketing conference are $30. Tickets to the keynote breakfast, which will be held on May 13 at 7 AM at Anthony's Pier 4 restaurant, are $20.

For more information, contact Electro-Mini/Micro Northeast, 8110 Airport Blvd, Los Angeles, CA 90045. Phone (213) 772-2965.

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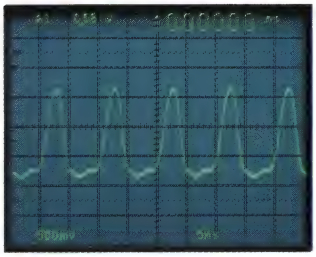
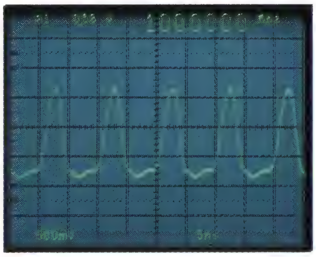
EUROPEAN HEADQUARTERS: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG Eindhoven, The Netherlands, (040) 458045, TLX: 51846.

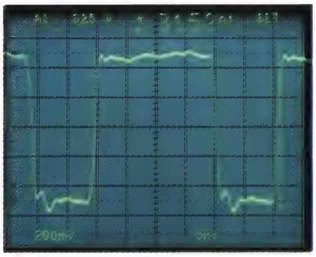
SIXTEEN TOUGH ASSIGNMENTS.



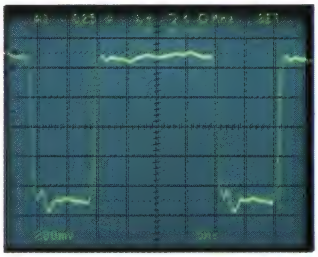
A period measurement is made on a 100 MHz clock using the extended accuracy and resolution of the Counter/Timer/ Trigger in the 2465 DVS.



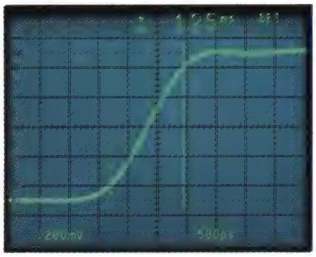
A frequency measurement is made with the same high precision. Simply press two buttons, and the period measurement on the left is converted to frequency.



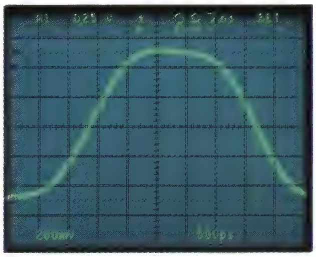
Short time intervals can be measured most accurately with the easy-to-use time cursors. They also make quick work of longer intervals, with 1% accuracy.



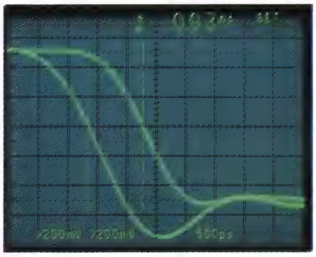
Calculated frequency takes only seconds. The time cursor measurement on the left can be converted to frequency with push-button ease and 1% accuracy.



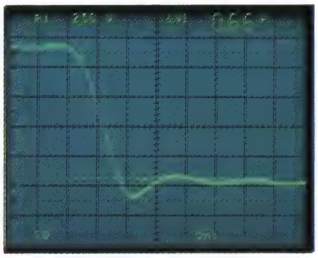
This fast-pulse rise time is nearly that of the scope. The 2465 achieves maximum bandwidth with minimum waveform aberrations. This level of pulse



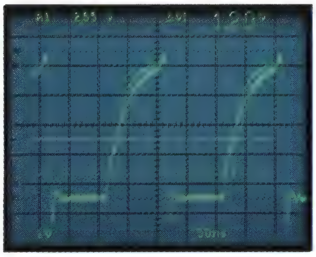
response ensures that **pulse width** and amplitude measurements on fast waveforms (above) truly reflect conditions in a circuit under test.



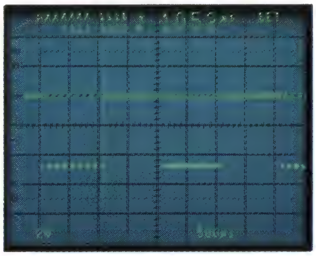
Propagation delay measurement accuracy is assured by built-in propagation delay matching. Delay between Channels 1 and 2 can be corrected to the probe tip.



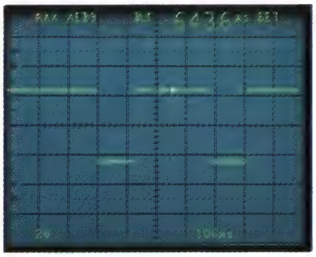
Overshoot and ringing measurement accuracy requires flat response in a probe/oscilloscope system. Tek probes and scopes are designed to work together.



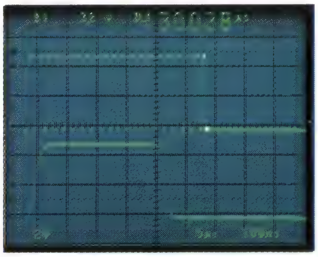
Logic-level violations can be spotted quickly on a TTL waveform (above) with measurement cursors set to define logic-level boundaries.



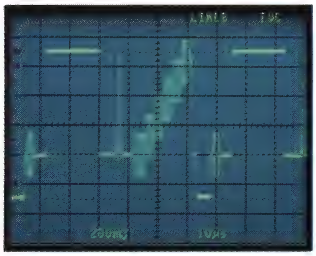
The Word Recognizer (with a binary word) is used to pick out a pulse train in a data stream. The time cursors measure pulse train duration.



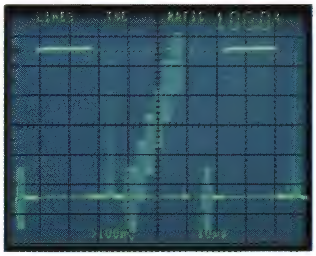
Identify a word position. The Word Recognizer (in HEX) is intensifying a word position and measuring delay relative to a waveform on another line.



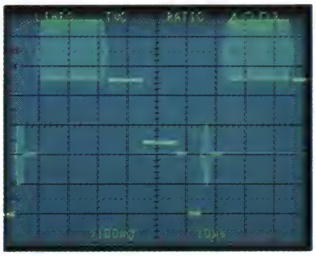
Delayed sweep is used to expand the last pulse in a pulse train. The intensified zone identifies the expanded pulse position.



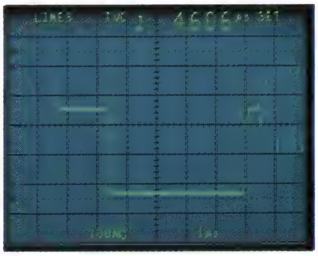
TV line trigger in the 2465 DVS displays a full-field composite test signal. The built-in TV clamp circuit removes hum and tilt on the ac-coupled video.



Calibrate cursors in IRE units with variable attenuation. Blanking level to reference white level is defined as 100 IRE units in NTSC video.



Burst amplitude should be 40 IRE units in NTSC video. The cursors quickly measure other waveform amplitudes. Field triggering checks any line.



Sync width and blanking are common, easy-to-make timing measurements. Accurate time measurements can be made anywhere in a video system.

FIVE EASY ANSWERS. THE TEK 2400 SERIES.

You can simplify even the most complex measurements with the performance and convenience of Tek's 2400 Series family. No other portable scopes meet such diverse requirements in research and design, manufacturing and service.

The 300 MHz 2465 and 150 MHz 2445 are at the foundation of the family. They include all the features that set a new high performance precedent. For example, standard delayed sweep Δ-Time to 0.5% accuracy. Coupled sweep speeds to 1 ns/div in the 2445 and 500 ps/div in the 2465 for tough timing measurements. And four-channel capability for observing and troubleshooting logic circuits.

Best of all, these stand-alone scopes are proof that powerful capability doesn't have to be complicated. Time and voltage cursors for fast and easy measurements, CRT readouts showing waveform parameters and front panel settings, and simplified trigger operation make these scopes a pleasure to use.

Features	2445	2465	2465 CTS	2465 DMS	2465 DVS
Bandwidth	150 MHz	300 MHz	300 MHz	300 MHz	300 MHz
Max. Sweep Speed	1 ns/div	500ps/div	500ps/div	500ps/div	500ps/div
Accuracy; Vert/Hor	2%/1%	2%/1%	2%/1%	2%/1%	2%/1%
Vertical Sensitivity	2 mV/div	2 mV/div	2 mV/div	2 mV/div	2 mV/div
Trigger Freq. Range	250 MHz	500 MHz	500 MHz	500 MHz	500 MHz
Trigger Modes	Auto Level, Auto, Norm, Single Sequence				
Counter/Timer/ Trigger/Word Recognizer	*	*	STD	STD	STD
DMM	*	*	N/A	STD	STD
Video/TV	*	*	N/A	N/A	STD
Four P6131 Probes	*	*	STD	STD	STD
GPIB	*	*	STD	STD	STD
Rackmount	*	*	*	*	*
Warranty	3-year on parts and labor, including CRT				
Price†	$3590	$5350	$7150	$8400	$9200

Software	
TEK GURU for IBM PC/XT/AT and 2445/65/GPIB	$595
EZ-TEK 2400 for TEK 4041 and 2445/65/GPIB	$400

*Configurable only at time of order. Additional cost required.

†Prices subject to change without notice.

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Three specially configured, specially priced Special Editions offer enhanced measurement capabilities for both systems and stand-alone use. At the top is the 2465 DVS with integral GPIB interface, DMM, Counter/Timer/Trigger/Word Recognizer, and Video measurement capabilities. Easily the most powerful portable ever developed.

The 2465 DMS and 2465 CTS are special editions with different feature sets. The 2465 DMS provides all the capabilities of the DVS except Video. The 2465 CTS provides all the features of the DVS except Video and DMM.

Call your Tek Sales Engineer for a demo today! Or call the Tek National Marketing Center toll-free, 1-800-426-2200. In Oregon, call collect, (503) 627-9000.

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COMMITTED TO EXCELLENCE

CIRCLE NO 185

"I Got Mad As Hell And Decided Not To Take It Anymore. . .

"My name is Roy Albano. I am a design services manager, whose responsibilities have ranged from selecting CAD systems to supervising engineers and PCB designers. My current employer, Diceon Electronics, Inc. of Irvine, California has been a leader in supplying state-of-the-art finished printed circuit boards to the majority of U.S. manufacturers—for applications in the commercial electronics industries. Throughout my many years of gaining knowledge and experience in PCB design, while working for other companies, **I went from observing laboriously tedious manual PCB layout methods to eventually ending-up a true believer in CAD as the only answer to improving efficiency and reducing product cost.** Countless times during this transitional period I was frustrated, had my designers spend long hours at the drafting boards and still, quite often, could not meet various design deadlines."

"So I recommended to one of my previous employers to get a CAD system, which was promising miracles and answers to all my PC design problems. We got this system and, after some time passed, I got mad. This CAD system fell far short of its seller's claims and left us basically operating nothing more than a glorified electronic pen and a screen to play with. So I looked long and hard and, in conjunction with other engineers, I decided to get a larger, seemingly far more sophisticated CAD system for PCB design. This was not at Diceon, but at another large electronics company in Southern California. The selected CAD machine utilized an automatic router, with solutions of at least (I was promised and verified it myself on small sample boards) 80-90 percent hook-up success. We were all impressed and bought it. We did not realize then that it would take us eight months to get familiar with this thing—although we were already fairly well experienced CAD users. Even after we had finally managed to understand the

Mr. Roy Albano
Manager of Design Services
Diceon Electronics, Inc.

"beast," we still ended up working manually nights and weekends to accomplish the job. And the last minute engineering changes—requested invariably just as we were about to complete the design—drove us bananas. That CAD system could not assist us in solving changes within a reasonable time frame. I think we spent so much time at work trying to accomplish the design tasks, satisfy the engineers, and fight our CAD system, that even my dog stopped recognizing me and would not let me into my own house without me first showing him proper I.D. . . ."

You see, a 90 percent routing solution sounds great, provided the PCB has about 300-400 traces to be connected. But today's typical PC boards have an average of 2000-6000 traces to be connected, and the missing 10 percent represents 400-600 lines that have to be "stitched in" manually. And these last lines are the most difficult ones, taking up the most time and yes, even a designer's zest for life.

"Yet, I continued hearing of great new things in CAD (which did not materialize) and I looked at some ten more CAD systems over the past 5 years. They were all long on promises, but short on true performance. **By this time, I knew well how to put CAD systems to the test through my own benchmark—still nobody seemed to fill the design needs we had.** I spent a lot of time visiting other electronics companies, discussing this dilemma with other PC designers, service bureaus, CAD users, and their managers and also visiting individual CAD vendors. In short, I gained a lot of additional experience in CAD and what it should do regarding the latest design criteria."

To the majority of decision makers in the fast-changing electronics industry, it is crystal clear that any company which can design a PCB faster than their competitors will be able to bring out a newly finished product to market even faster—thus gaining invaluable marketing, sales, and time advantages.

"My present employer, Diceon Electronics, Inc., can easily qualify as one to consistently offer new, reputable, and reliable products to the marketplace. In order to get these new products to market as quickly and efficiently as possible, we needed a superior CAD system. So I got mad as hell and decided not to take it anymore and began demanding (quite vocally) from the existing CAD vendors to provide us with a meaningful tool for PC design—but I got nowhere. . . .**until I discovered Calay!"**

"By pure coincidence, about 2 years ago, I heard from someone about a new CAD system recently introduced in the U.S. called Calay. This was in 1983 and we saw no flashy ads, no evidence of aggressive marketing—not even a salesman from Calay to call us. After a few inquiries, we found out that some of the best service bureaus and the toughest large manufacturers of electronic equipment were in fact already using a Calay VO3 System for their PC designs. We made numerous phone calls and what we heard from these existing

. . .Until I Discovered Calay"

users of Calay sounded almost too good to be true. We called Calay and spoke to Dick Finn, their General Manager, and the ensuing conversation prompted me to make sure that, this time (in addition to our other engineers), I was personally going to verify the facts. I did not want to spend big money on promises alone."

Diceon people contacted Wolfgang Schenke, the Calay Vice President of R&D, and arranged a benchmark with him. **Calay's benchmark criteria were not like anything they'd ever done or heard of before.** To maintain true results and credibility, the Calay people insisted that no information be given about the test by Diceon to Calay ahead of Roy's arrival at Calay. No net list, no placement, no component description, not even any portions of schematics or board outline. The job was to be done "from scratch"—thus simulating the Diceon production environment, in order to get a meaningful assessment of Calay capabilities.

"**Since that time, we have utilized exclusively Calay systems for our facility—and Diceon Electronics has grown and continued to be viewed as one of the best recognized and profitable technological leaders in its field.** Calay's technical staff has been supporting us fully and we learned to appreciate their candor, straightforwardness, knowledge, and credibility. The Calay System is the only one so far I have had full confidence in. No more long hours and weekends spent on designs—and I became friends with my dog again. . .**I also experienced the awakening that Calay is really what CAD is all about,** and we got our toughest PC boards designed faster on Calay and, as a result, we get our product out on the market ahead of our competition."

Mr. Chris Christofferson
Manager of Engineering Services, Sun Microsystems, Inc.
Mr. Richard A. Finn
President & CEO ,Calay Systems, Inc.

Typically, PC boards are Calay-routed day, night, or during weekends without operator presence or assistance. **Even complex digital or analog boards, multilayer boards, chip carrier (SMD) boards, odd-shaped boards, and those very dense boards.** No more long hours to find the solution—the Calay VO3 CAD System does it 100 percent in most cases. The system is magnificently user friendly, simple and user definable. It is even more efficient when interfaced to any CAE workstation for schematics generation, including back-annotation. **And the Calay router is truly AWESOME.** Coupled with on-line design rule check and easy creation of new library components, high resolution graphics, and **powerful interactive features** the Calay System offers not only the premier solution, but also the complete solution for PCB design. Starting at the net list and the component creation and placement, to the routing and post processing documentation, Calay reliably takes the user from the beginning to the successful end of the total design cycle. **Users don't have to worry about engineering change orders anymore because Calay's flexibility allows them to make all the changes they want without requiring them to start the design or routing process all over again.**

"As a result, Diceon products deliver more state-of-the-art capabilities than our competition. In fact, our cost to design and manufacture PC boards is extremely reasonable. You see, with the Calay System, we get both fast turnaround and boards that can be economically manufactured."

"**At Diceon Electronics, we can't afford to be second best.** That's why we have Calay CAD Systems in our design engineering department supporting us day-in and day-out. Maybe you can't afford to be second best either. . ."

So if you're mad as hell, you don't have to take it anymore. Do what Roy did—give Calay a call.

Corporate Headquarters:
CALAY SYSTEMS, INC.
2698 White Road
Irvine, CA 92714
(714) 863-1700, Telex 6711321

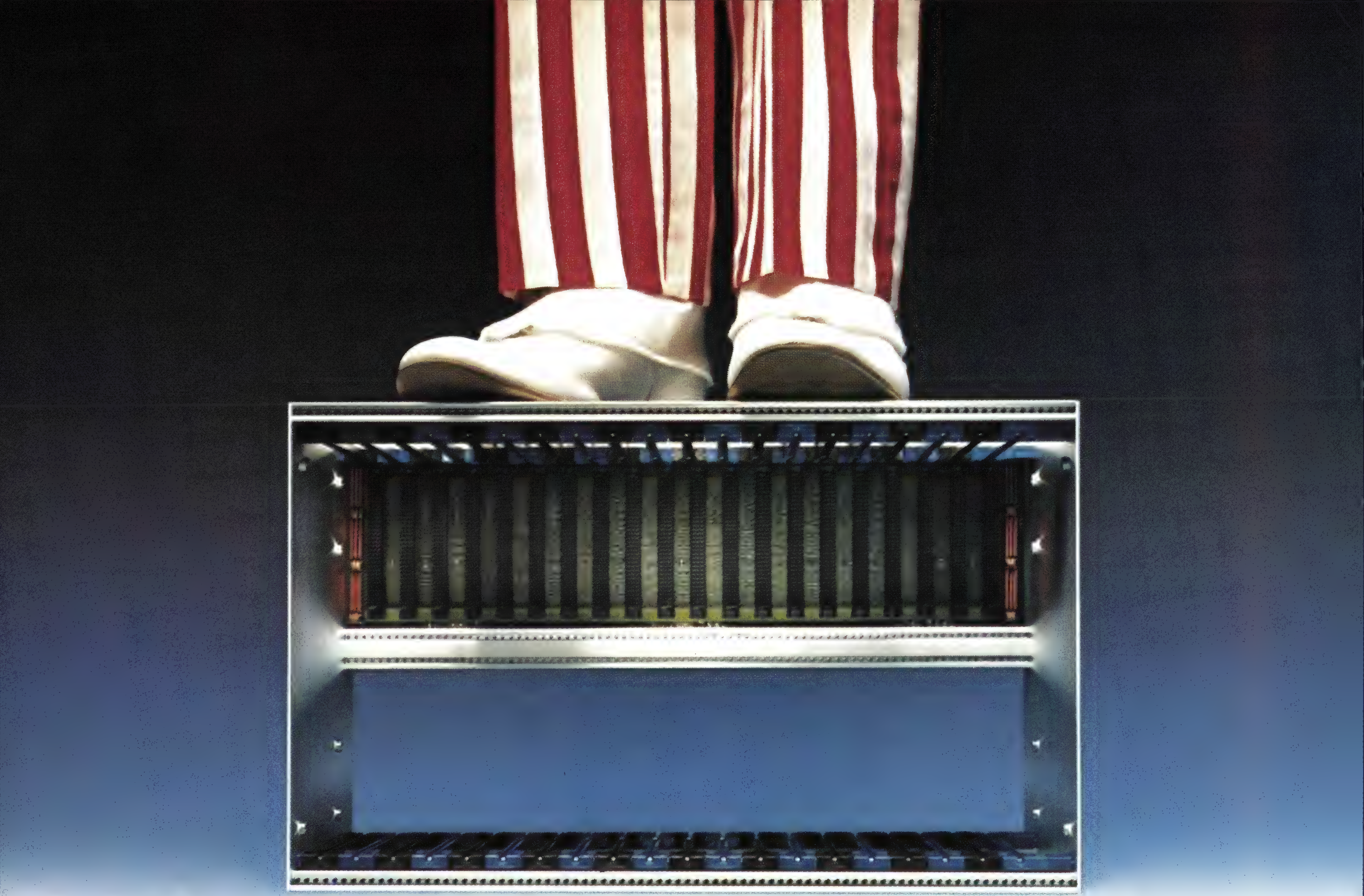
Regional Offices:
4633 Old Ironsides, Suite 403
Santa Clara, CA 95054
(408) 748-1901

70 Walnut Street
Wellesley, MA 02181
(617) 239-8111

European Contact:
CALAY EUROPE
6050 Offenbach/Main
Heinrich-Krumm Str. 5
Tel. (0611) 892-065, Telex 041 52775
West Germany

CALAY

Advanced CAD for Printed Circuit Board Design



The Americanized VME Card Cage. We Stand On Our Reputation.

One reason Electronic Solutions became the world's leading supplier of Multibus card cages is that five generations of improvement gave our cages a reputation for indestructibility second only to a rock.

So when we decided to build an Americanized version of the VME card cage it was only natural that we would want to build it the same way. Because European kit-style cages don't measure up when it comes to strength.

Introducing Electronic Solutions V-800 Series VME Card Cages. We took a stand for ruggedness and rigidity. Right on top of them — to prove that a V-800 card cage could maintain its precise card alignment through thick and thin.

Rigidity gives your VME cards less room to flex and that means less room for things to go wrong. Connectors stay connected. And so do printed circuits. So when your system is shipped, moved, or dropped from a forklift the odds are a lot better that it will remain functionally intact.

But that's not the only part of our reputation we built into our VME card cages.

Our V-800 Series cages feature advanced, low-noise, high-performance backplanes designed for the fastest VMEbus signals. You can mount our new cages on any axis. And you can use our exclusive center adapter to convert any double slot to two singles or any triple size slot to a double and a single.

Electronic Solutions V-800 Series VME card cages. Step up to the best there is.

Call toll free or write for complete information today.

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CIRCLE NO 187

Networking products link VAXs, IBM PCs, and Intel μP development systems

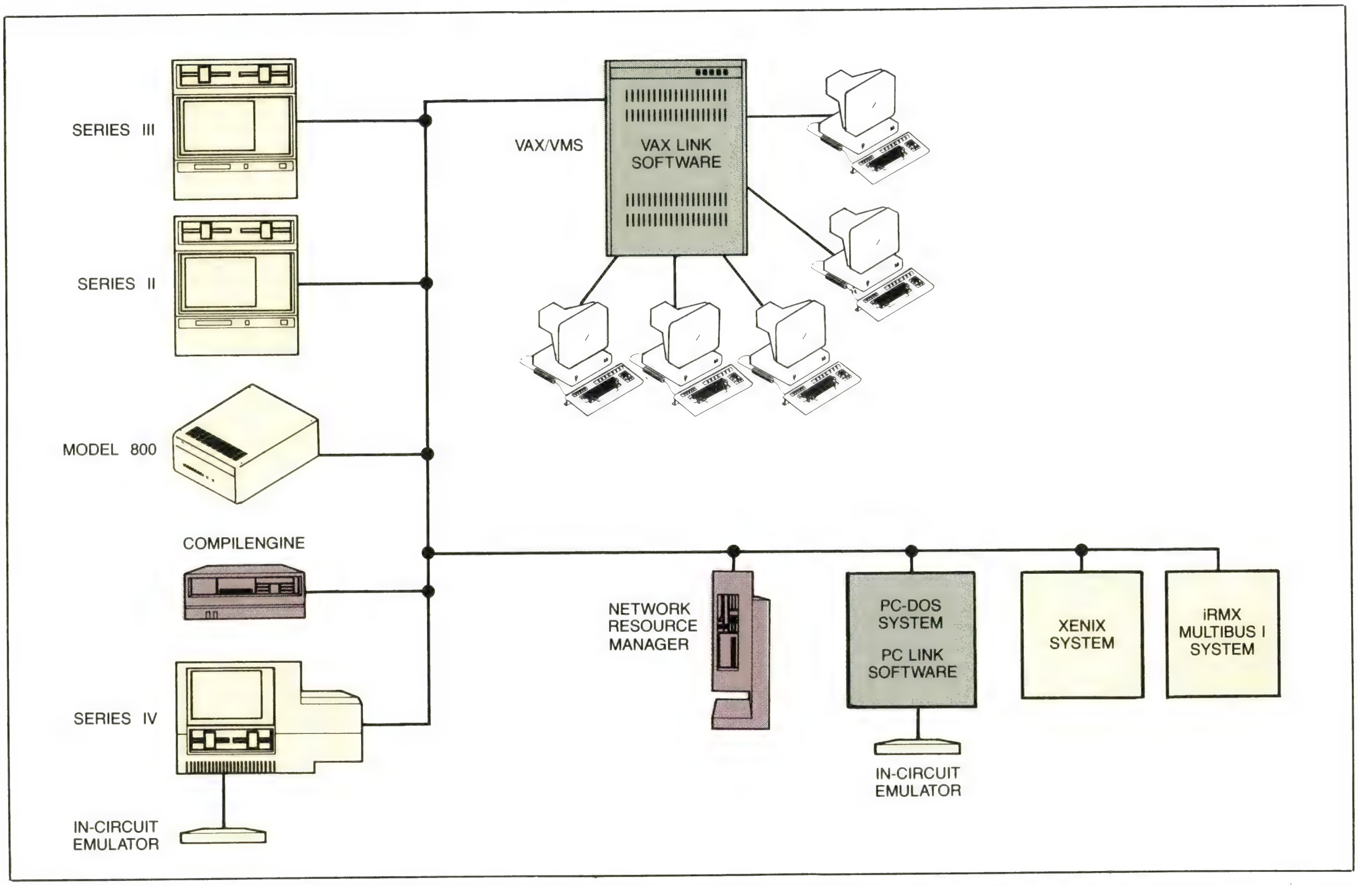
Intel μP development systems and software now work with host computers other than Intel products. The Open Development Networking products link DEC VAXs, IBM PCs, and the company's development systems and System 310 computers.

The Open Development Networking products presently include two pieces of hardware and two communications programs. The hardware products are the Network Resource Manager (NRM) and the Compilengine. The two software packages, VAX Link R2.1 and PC Link, connect the NRM with VAXs and PCs, respectively, via Ethernet.

The NRM is a 560M-byte file server with its own local processors and two Ethernet ports. Any workstation on the network can gain access to files stored in the NRM's protected hierarchical file system; this operation is transparent to the user. The NRM also handles shared resources such as tape archiving and spooled printing. In addition, the NRM can distribute job control to idle development systems in the network, to the VAX, or to the Compilengine.

The Compilengine is a specialized computer that handles time-consuming compilations and module linking. According to Intel, the Compilengine runs typical μP compilation jobs 35% faster than an IBM PC/AT, twice as fast as a VAX 11/780 (with a single user), and five times faster than an Intel Series IV development system.

The VAX Link R2.1 software package enables file copying and distributes job control between VAXs running VMS R4.2 and the Intel NRM. The VAX Link software uses a VAX computer's Ethernet board for I/O and is compatible with—but not a part of—Decnet.



Now you can share software-development tasks *among VAXs, IBM PCs, and Intel μP development systems that are all connected in an Ethernet network. The Network Resource Manager, the Compilengine, and the VAX Link and PC Link software packages combine to let you share files and distribute job control among the available resources.*

The PC Link software works with an add-in Ethernet controller plugged into an IBM PC/XT or PC/AT. The board has its own local processor and memory. The PC user gains access to files on the NRM as though they were stored on PC-DOS drives. The software also supports remote printing. The software's file servers communicate with Intel Xenix or RMX-86 systems. The company also offers a standard Multibus I Ethernet communications board that allows you to connect board-level systems to the network.

The products are based on the International Standards Organization's 7-layer Open Systems Interconnect model for networking. The NRM with a 40M-byte hard disk costs $14,995—$23,995 with a 140M-byte disk and a 60M-byte streaming tape drive. The Compilengine costs $13,995. The PC Link software and add-in board together cost $1250, and the VAX Link software sells for $7500.—***Charles H Small***

Intel Corp, Literature Dept W274, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080.

Circle No 732

Arbitrary-waveform synthesizer creates 50-MHz waveforms

The $24,000 Hewlett-Packard HP 8770A arbitrary-waveform generator creates waveforms that have significantly higher bandwidths than any other available generator can manage. The 8770A generates 50-MHz (max) waveforms at 125M samples/sec with 12-bit resolution; all other available 12-bit arbitrary-waveform generators run at less than 40M samples/sec.

The generator's 50-MHz analog output ranges from 2V p-p (+10 dBm) down to −100 dBm. Harmonic distortion is less than −50 dBc, and nonharmonic distortion is below −60 dBc. Two-tone linearity is under −57 dBc for a 124-kHz separation, and single-sideband phase noise for a 10-MHz signal is typically −125 dBc/Hz at a 10-kHz offset.

At 125M samples/sec, the instrument could run through its sample memory very quickly. But the 8770A combines a 128k-sample pattern memory with a sequencing function that can repetitively reuse specified portions of memory to provide extended output waveforms of long duration.

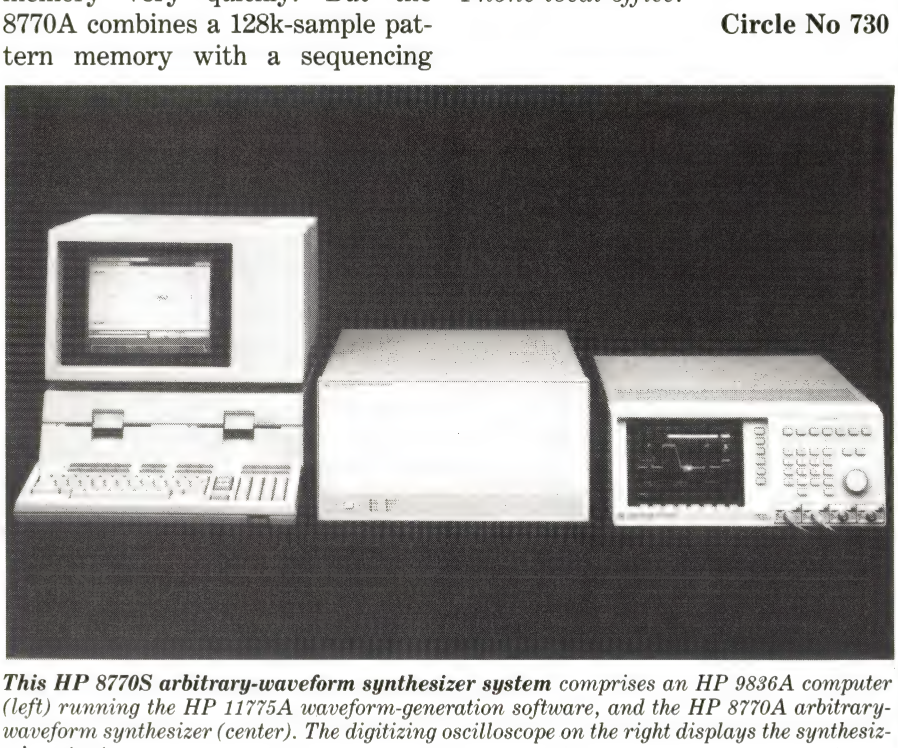
The 8770A and the $5000 HP 11775A waveform-generation software compose the waveform-synthesis system. The software package runs on HP 9000 Series 200 computers. With the aid of the software, you can create and modify complex waveforms. The package's FFT routine allows you to specify your waveform in either the time or frequency domain.

In operation, you define your waveform mathematically, describing its segments or constructing them by using menu selections. Delivery, 16 weeks ARO.

—Charles H Small

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 730



This HP 8770S arbitrary-waveform synthesizer system *comprises an HP 9836A computer (left) running the HP 11775A waveform-generation software, and the HP 8770A arbitrary-waveform synthesizer (center). The digitizing oscilloscope on the right displays the synthesizer's output.*

Low-cost STE Bus-based development systems target 8/16-bit I/O and control designs

The STE Bus-based PII-DS-S1 and PII-DS-S2 development systems allow you to build 8/16-bit μC designs for low-cost, STE Bus I/O and industrial-control applications. The system enclosure has room for the development-system boards and for a number of target-system boards as well. The basic development-system components include a CPU board, associated development software, an SCSI board, a disk-controller board, and a system enclosure with two floppy drives and a Winchester drive—all for less than $5000.

STE Bus systems use single-height Eurocards and a substantially simpler interface than the VME Bus. Because of the Eurocard form factor, an STE Bus system is physically compatible with VME and Multibus II systems and can even serve as an I/O subsystem for the high-end buses. Designers of STE Bus-based I/O and control systems now have a variety of general-purpose CPU, peripheral-controller, memory, and other boards to choose from. The PII-DS-S1 and -S2 development systems provide the engineer with a means for designing the custom boards typically required in the I/O and control environments.

The two development systems offer identical hardware with the exception of the CPU boards. The -S2 CPU board includes an 8-MHz Motorola 68008 μP, 512k bytes of dynamic RAM, and two serial channels. The -S1 CPU board has two DMA channels, two serial channels, an MMU, 256k bytes of dynamic RAM, and a 6.144-MHz 64180. Both boards act as the bus arbiter and system controller in an STE development system.

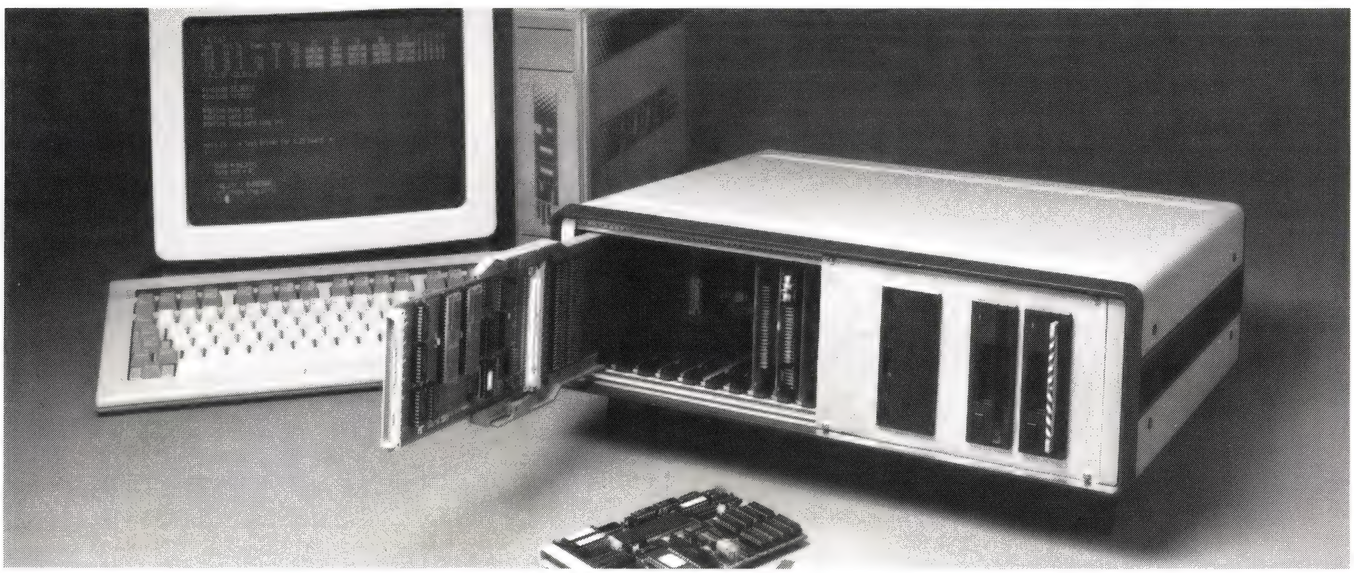
Development-system peripherals include dual 3.5-in., 1M-byte floppy disks and a 3.5-in., 25.5M-byte (unformatted) Winchester. An STE Bus SCSI host adapter interfaces to the Winchester; a dedicated controller handles the floppy-disk drives.

A 19-in. rack-mountable chassis provides the mechanical backplane for all the development-system components. The standard development system only uses three of the backplane's 10 STE Bus slots, so you can use the backplane to hold part or all of your target system. The standard system comes in a 21-in. ruggedized enclosure. It operates from a 250W switching power supply.

Software options vary between the two development systems. The 68008-based CPU board includes the multiuser, multitasking PDOS operating system. For 64180-based systems, the user may choose the CP/M+ or the ZRDOS operating system. All operating systems include some development tools, such as an editor, linker, and assembler. Software offerings from a variety of vendors support the three operating systems.—***Maury Wright***

Performance Interconnect Inc, 8950 Villa La Jolla Dr, Suite 2144, La Jolla, CA 92037. Phone (619) 457-0665.

Circle No 729

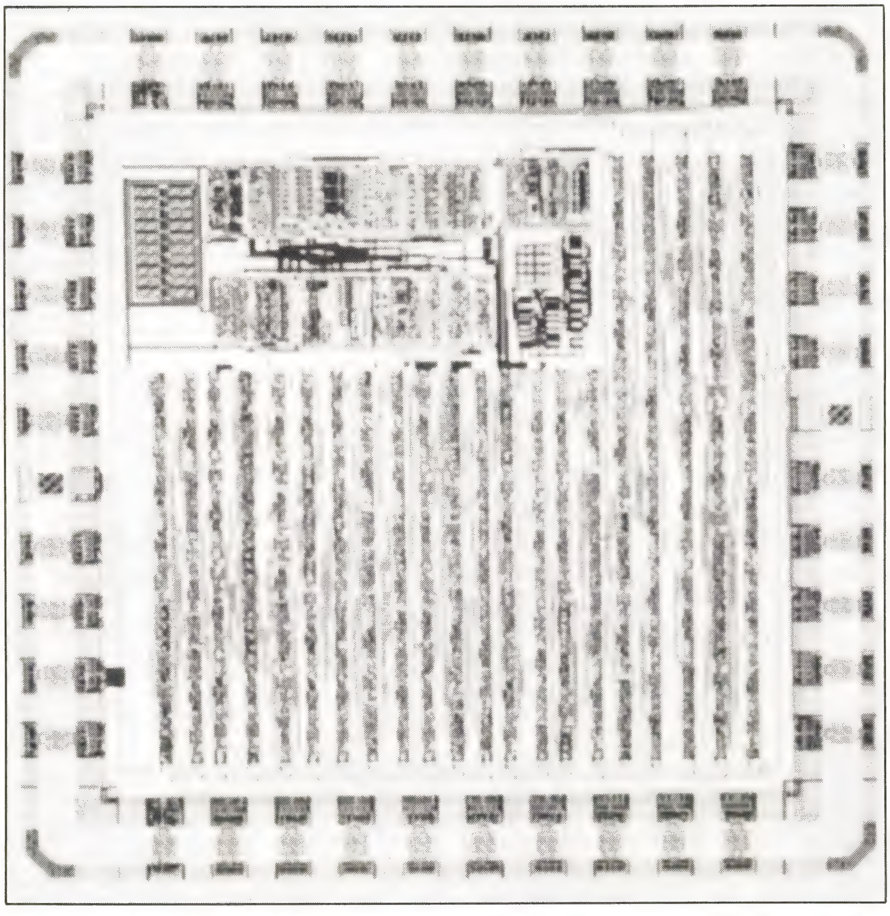


Because the basic system boards occupy only three of 10 available slots *in the system backplane, the PII-DS-S1 and -S2 development systems accept part or all of your STE Bus I/O or control target system.*

Electrically erasable standard memory cells yield custom ICs with nonvolatile memory

You now can create a custom IC that includes nonvolatile memory by using the first available electrically erasable standard memory cells. These cells are compatible with the manufacturer's digital and analog standard cells, so you can integrate linear and memory functions with digital logic. The nonvolatile memory cells allow you to add configuration and adjustment features to your circuit.

The electrically erasable cells are fabricated using a 2-μm CMOS technology. The vendor has integrated as many as 8k bits of electrically erasable memory on one IC, although it stresses that the cells are most useful for small amounts of storage. Large memory blocks use silicon inefficiently because of the relatively large size of the electrically erasable cell. The memory cells have parallel data-storage bits for redundancy (ie, each memory cell stores its data on two separate transistors), thereby increasing the effective yield of the IC. Differential sensing allows the overall chip supply voltage to vary between 3 and 6V. The cells have the typical endurance specifications for electrically erasable devices—10,000 cycles and 10-year data retention.



__The first electrically erasable standard memory cells__ implement nonvolatile storage in this IC design. The electrically erasable cells are compatible with the vendor's digital and analog standard cells.

In addition to the memory cell, the company offers high-voltage generator and interface cells. These cells provide the voltages and programming signals required to write data to the electrically erasable cells. Each memory cell is embedded in a digital flip-flop and latch so it can operate directly with other on-chip logic; you don't need to worry about the details of writing to and erasing from the electrically erasable cells.

The nonvolatile memory cells are useful as replacements for conventional adjustment components like potentiometers and DIP switches. For example, a nonvolatile register can store calibration settings, I/O format selections, or system access codes. In potentiometer applications, the memory cells can work with on-chip analog cells to form a linear adjustment circuit that's digitally controlled. In addition, by building a chip with nonvolatile memory, you can automate system-test, calibration, and maintenance operations.

To create your chip using the electrically erasable cells, you submit your system design and specifications to the manufacturer. It charges between $5000 and $25,000 for the design, depending on the complexity, and approximately $30,000 for the tooling and fabrication of prototypes. The unit cost of production devices is $0.0015/gate typ.—***David Smith***

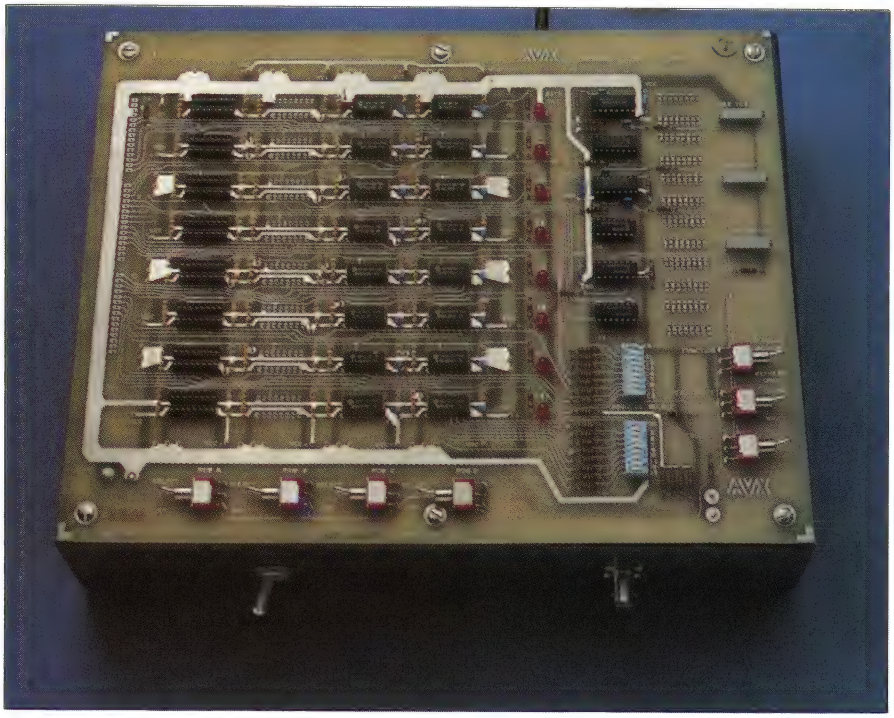
Sierra Semiconductor Corp, 2075 N Capitol Ave, San Jose, CA 95132. Phone (408) 263-9300.

Circle No 727

Decoupling IV

AVX Techfile Series

TECHNICAL INFORMATION FROM THE LEADER IN MLCs



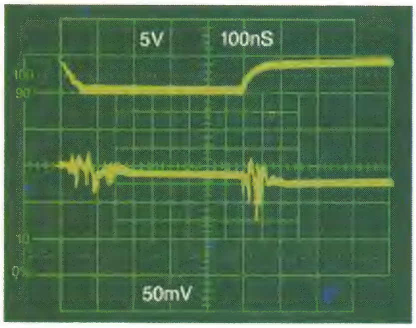


Fig. 2. Scope traces for refresh cycle on 256-K DRAM test board with 0.33-μfd AVX MLCs.

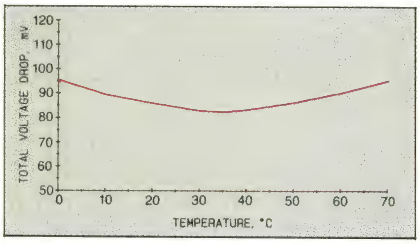


Fig. 3. Effect of temperature on 256-K DRAM decoupling with 0.33-μfd AVX MLCs (Z5U).

MLC Decoupling of 256-K Dynamic RAMs

A dynamic RAM's sensitivity to decoupling-induced "soft-errors" (random loss of one or more bits of memory) increases dramatically with higher speeds, higher density, and an increased number of sense amplifiers. The new 256-K DRAM designs have large, instantaneous current demands which must be satisfied by a local current source.

That source is the decoupling capacitor directly adjacent to the RAM package. And the capacitor most often used for this application is a multilayer ceramic capacitor (MLC) because of its low series inductance, low series resistance, and high capacitance in a small size.

Test Results

Tests were conducted by AVX on a 256-K DRAM memory board to determine the noise level obtained with various values of MLC capacitors. Figure 1 compares the results obtained using 256-K DRAMs with those from similar board tests on 64-K DRAMs. As indicated, 0.33-μfd capacitors are required on the 256-K DRAM board to obtain a noise level equivalent to that obtained using 0.1-μfd capacitors on the 64-K DRAM board. Performance improvements on the 256-K DRAM

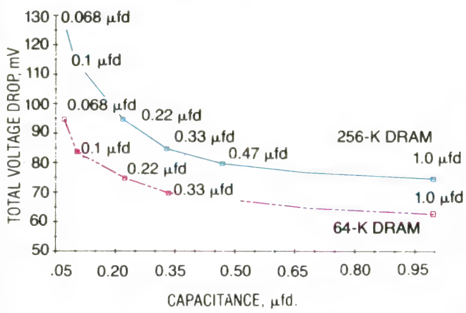


Fig. 1. Decoupling characteristics for 64-K and 256-K DRAMs with AVX MLC capacitors (including V-bump and V-droop).

test board leveled off between 0.33-μfd and 1.0-μfd, indicating that the preferred value for decoupling is about 0.33-μfd.

Figure 2 shows the scope traces obtained during refresh cycle on the 256-K DRAM test board with a 0.33-μfd AVX MLC. In all tests, the general decoupling scheme used was one MLC capacitor for each DRAM, with no board-level bulk capacitors.

Discussion

General-application ceramic formulations, such as Z5U, show considerable change in capacitance with temperature. However, this change has little affect on the total noise level for 256-K DRAM when the correct value is chosen. Thus, the 0.33-μfd value is high enough to meet the 256-K DRAM's current requirements over its full operating temperature range, as shown in Fig. 3.

For a complete technical paper describing these tests in detail, complete and return the coupon below.

☐ Please send me the AVX Technical Paper, "Decoupling 256-K DRAMs."
☐ Please send me literature describing AVX MLCs
☐ Please send me samples

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AVX Technology For The Times

CIRCLE NO 189

Low-cost, PC-based LAN rivals Ethernet with 300k- to 450k-bps effective data rates

The Microlan 1553-Net local-area network provides twice the effective data bandwidth as a similar Ethernet configuration at approximately one-half the cost, according to the manufacturer. Microlan controller boards fit into the short slot in IBM PCs, PC/XTs, PC/ATs, and compatible systems and come with software that features pop-up windows and 100 levels of security. Microlan boards are also available for Apple II computers and systems employing the S-100 Bus.

Although the Microlan network has a lower specified bandwidth than an Ethernet network (3M bps vs 10M bps), the company states that the network's encoding techniques result in an effective data-transfer rate of 300k to 450k bps, a higher rate than Ethernet's estimated 100k-bps effective rate. One Microlan network can comprise as many as 253 nodes. The nodes connect to a 50Ω coaxial cable by means of BNC connectors. The cable can be as long as 1500 ft. A Microlan board requires at least 128k bytes of memory and draws 0.5W from the PC's power supply.

The board implements a LAN protocol that's a derivative of the MIL-STD-1553 military-aircraft communications protocol. A CRC algorithm checks data blocks; the board also performs parity checking and Manchester encoding. For arbitration of bus usage, the network uses carrier-sensed multiple access/collision detection/collision avoidance (CSMA/CD/CA) techniques. These techniques prevent two or more nodes from transmitting data at the same time.

The vendor's network software, PC-NOS, runs in the background to execute network programs, gain access to remote data, and prevent data destruction, which can be caused by simultaneous access of files. The software works under PC-DOS 2.0 or MS-DOS 2.0 to allow PCs on the network to share files and such hardware resources as disks, printers, keyboards, displays, modems, clocks, and gateways to other networks. Once a connection to a remote resource is established, the resource sharing is transparent to the user. The software includes commands to attach and disconnect your PC to remote devices, and to lock files that are on your PC so that other PCs can read them but not write to them. All PC-NOS routines are available in Basic, Fortran, assembly, and Forth languages.

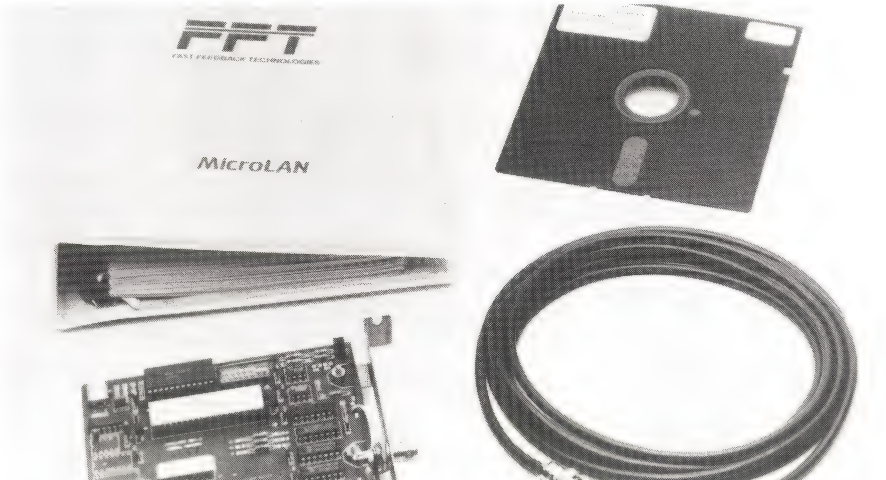
The main program in the software, Server, executes as a command (.COM) file. It initializes itself and then returns control to the operating system after it sets its break address, so that the operating system will not write over it. Server uses interrupt vector INT 13H to intercept and service calls for remote files.

When you log on to a Microlan network, the system asks for a password and then establishes access and security privileges. Access control is hierarchical, extending from nodes down to peripherals, directories, and files.

A Microlan card costs $350. An XL version contains ROM to allow a diskless node to boot up from another node; this card costs $450. A Lanstarter kit includes two Microlan cards, the PC-NOS software, manuals, and a 25-ft cable for $1150. A network-expansion kit is identical to the Lanstarter kit except that it has one card and costs $575.—***David Smith***

Fast Feedback Technologies, 1505 Aviation Blvd, Redondo Beach, CA 90278. Phone (213) 379-6100.

Circle No 726



Furnishing effective data rates of 300k to 450k bps, *the Microlan local-area network costs less per node than other networks with similar configurations, according to the manufacturer. Plug-in boards are available for IBM PCs and compatibles and for Apple II and S-100-based computers.*

Single unit combines voltmeter and high-speed, 8-bit digitizer

At first glance, the Model 194 looks like just another system voltmeter. But behind the instrument's front panel is a 1M-sample/sec, 8-bit digitizer and waveform-analysis software along with the expected 4½-digit voltmeter.

The instrument comes with built-in waveform-analysis routines for averaging, true-rms calculation, integration, and determining standard deviations and peak-to-peak readings. The 194 also identifies the positive peak, the negative peak, and the value of the sample at the trigger point. When an optional second channel is installed, the instrument becomes the Model 1944 system voltmeter, which computes the ratio and difference of parameters from each channel.

The instrument can store 64k 8-bit samples; because the 4½-digit voltmeter mode is equivalent to 16-bit digitization, you can store only 32k 16-bit samples in that mode. The maximum reading rate in the 4½-digit mode is 100k samples/sec.

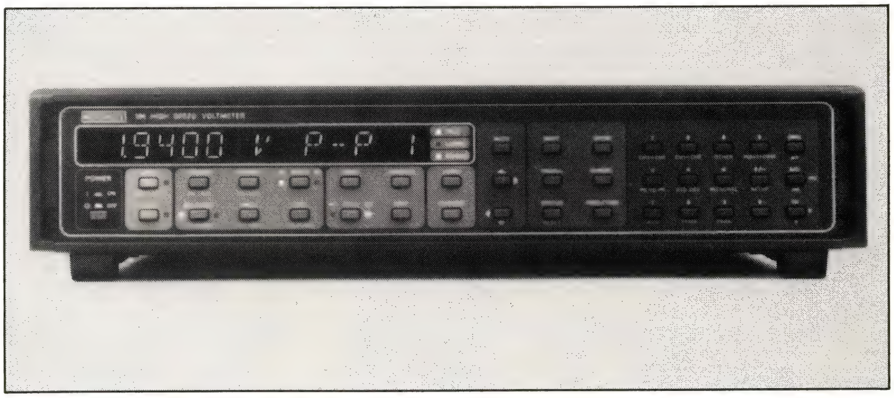
In the 4½-digit mode, the instrument's dynamic range is 10 μV to 200V; in the high-speed, 8-bit mode, the resolution is 2.56 mV. The meter can store either pretrigger or post-trigger data. The programmable sample period, ranging from 1.0 μsec to 1.0 sec, has a minimum increment of 0.1 μsec over the entire range.

The unit operates from any of five trigger sources. It provides an IEEE-488 interface for external control. In DMA mode, the unit transfers data at 90k bytes/sec over the IEEE-488 bus. Furthermore, internal software can expand a short mnemonic into an elaborate command string, thus lowering IEEE-488 bus overhead. The software can also translate command strings for other brands of voltmeters into strings comprehensible by the 194.

You can set the unit's input filter for a full bandwidth of 750 kHz, or you can use one of two lowpass filters—50 kHz or 500 kHz. $3995; the 2-channel Model 1944 adds $1895.—***Charles H Small***

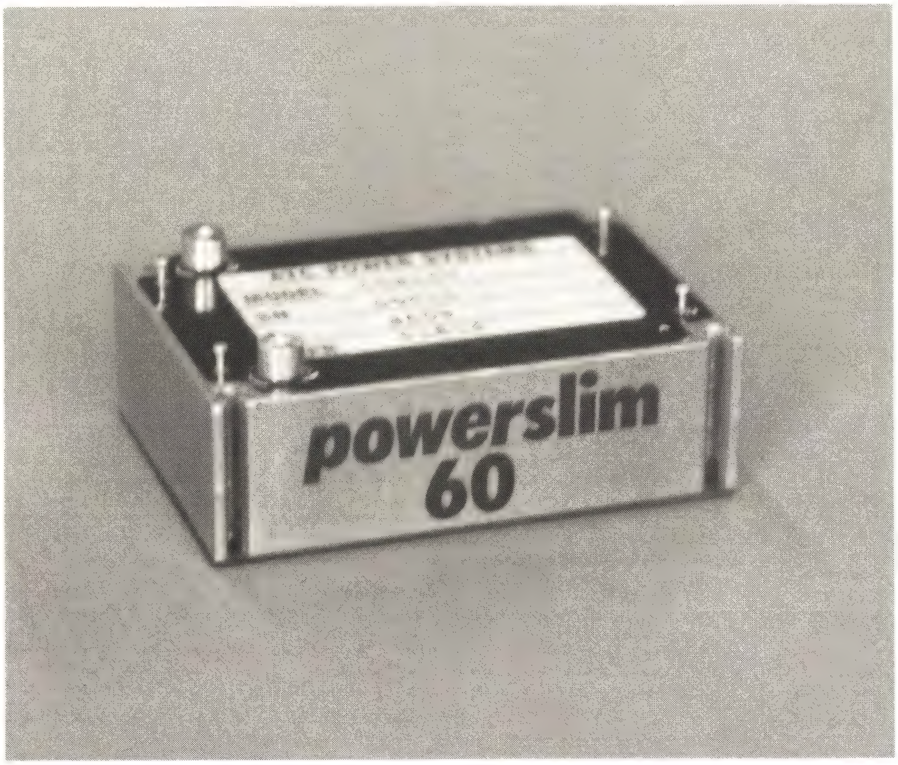
Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

Circle No 731



Combining a high-speed digitizer *with a system voltmeter, the Model 194 spans the sampling-speed gap between voltmeters and digitizers. The 194 covers the 100k- to 1M-sample/sec range.*

60W switching power supply offers 5 or 15V at 10W/in.^{3}



Because it uses a 250-kHz switching frequency, *the Powerslim 60 delivers 5V±1% at 12A or 15V±1% at 4A from a 2×3×1-in. package.*

The Powerslim 60 operates at a 250-kHz switching frequency, which allows the 2×3×1-in. module to deliver 60W—yielding a 10W/in.^{3} power density. The single-channel supply accepts a 28V dc nominal input (18 to 40V dc). You can select from two output ratings: 5V±1% at 12A or 15V±1% at 4A.

Line and load regulation spec 0.1 and 0.5%, respectively. The temperature coefficient is 0.03%/°C. Ripple measures 1% p-p from dc to 100 MHz.

The Powerslim 60 settles within 0.5 msec in response to a 50 to 100% load change. Overshoot and undershoot are limited to 100 mV. The supply, which features output short-circuit protection, meets MIL-461 emissions standards and withstands input transients in accordance with MIL 704. $850.

(For more on high-frequency switching power supplies, see pg 130.)

ATC Power Systems Inc, 472 Amherst St, Nashua, NH 03063. Phone (603) 882-1366.

Circle No 728


FEW REMEMBER WHO WAS SECOND TO SOLO THE ATLANTIC...
OR SECOND
IN THE MARKET...

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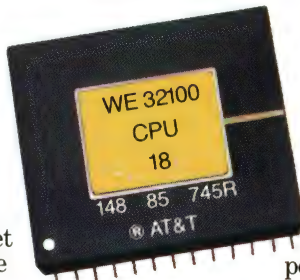

WE®32100, heart of the first full 32-bit chip set.

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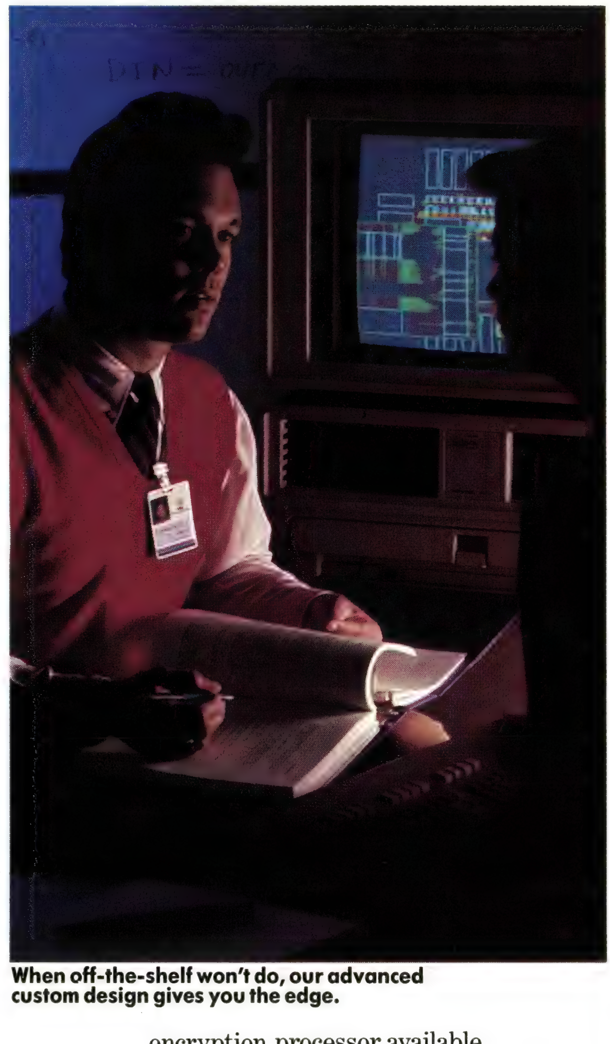
Right now, for example, AT&T is the only company in volume production of a microprocessor-controllable, single-package modem that can handle up to 2400 bits per second.

Our Digital Encryption Processor is the only software-programmable, encryption processor available.



When off-the-shelf won't do, our advanced custom design gives you the edge.

And our X.25 Protocol Controllers offer the widest range of applications, from PCs to satellites.

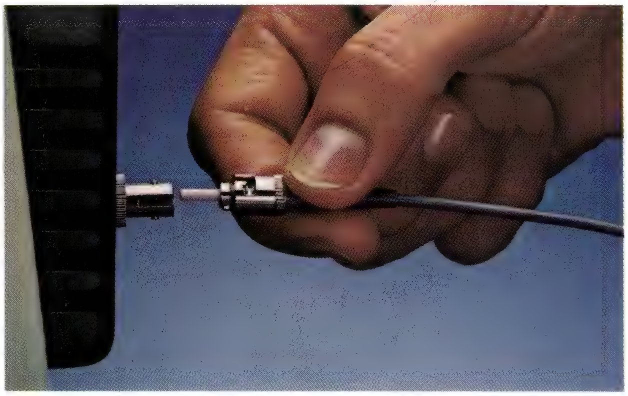
In memory, not only are we currently delivering an American-made 256K DRAM, but we offer a range of

Few remember James Mollison, the second man to fly solo across the Atlantic, because 'Lindy' did it first.

PROMISE YOU JUST THE FASTEST AN IDEA FLY.

leading-edge specialty memories.

And our third-generation, single-chip Digital Signal Processor gives you the edge you need to design-in superior system performance at a competitive price.



New ST™ Connector doubles your connections.

Count on AT&T's advanced technology to help you move your product out the door on schedule.

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Your specialized interconnection needs will be taken care of—from flexible printed wiring to multilayer boards to hybrid ICs—all produced with our high standards of quality and reliability.

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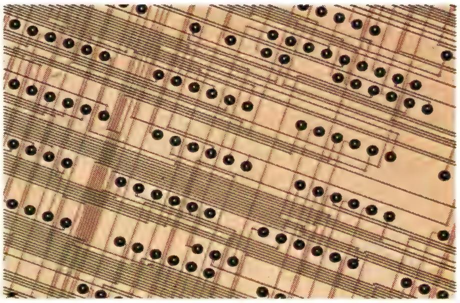
Our newest addition to the AT&T lightwave family—the ASTROTEC™ ceramic laser module—is a reduced-size, long-wavelength laser that offers highly reliable, low cost performance.



Advanced processing technology provides superior buried microvias in multilayer printed wiring boards.

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CIRCLE NO 191

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CIRCLE NO 192

LEADTIME INDEX

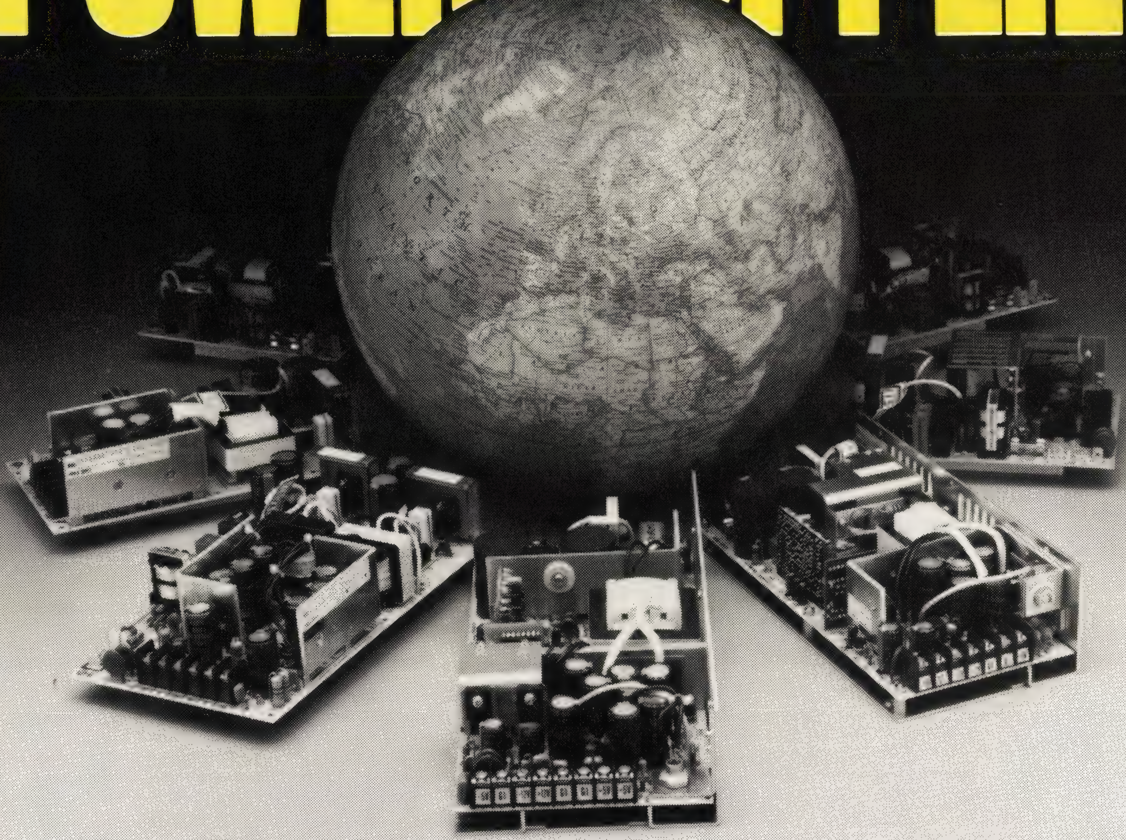
Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	18	27	55	0	0	11.3	7.8
Pot-Core	0	22	45	33	0	0	9.3	9.1
Laminate (power)	0	21	57	22	0	0	8.4	7.3
CONNECTORS								
Military panel	14	0	72	14	0	0	8.0	10.9
Flat/Cable	15	54	31	0	0	0	3.5	5.0
Multipin circular	11	22	45	22	0	0	7.6	10.6
PC	13	40	47	0	0	0	4.5	7.3
RF/Coaxial	0	40	60	0	0	0	5.6	8.0
Socket	25	44	31	0	0	0	3.4	4.5
Terminal blocks	14	52	33	0	0	0	3.7	4.7
Edge card	11	44	45	0	0	0	4.4	4.4
Subminiature	8	75	17	0	0	0	2.8	3.7
Rack & panel	0	40	60	0	0	0	5.6	6.7
Power	0	33	56	11	0	0	6.9	5.6
PRINTED CIRCUIT BOARDS								
Single-sided	0	65	35	0	0	0	4.1	4.0
Double-sided	0	50	50	0	0	0	5.0	4.3
Multilayer	0	10	60	30	0	0	9.8	6.2
Prototype	0	100	0	0	0	0	2.0	2.8
RESISTORS								
Carbon film	44	24	32	0	0	0	3.0	2.6
Carbon composition	26	26	37	11	0	0	5.2	3.5
Metal film	39	30	31	0	0	0	3.0	2.6
Metal oxide	33	27	40	0	0	0	3.7	3.6
Wirewound	14	36	50	0	0	0	4.7	4.9
Potentiometers	8	42	46	4	0	0	5.2	5.4
Networks	40	20	20	20	0	0	5.2	3.5
FUSES	35	45	20	0	0	0	2.5	1.6
SWITCHES								
Pushbutton	29	24	41	6	0	0	4.7	3.5
Rotary	7	22	57	14	0	0	7.3	5.2
Rocker	15	39	23	23	0	0	6.3	4.0
Thumbwheel	0	18	46	36	0	0	9.8	5.4
Snap action	22	45	11	22	0	0	5.3	4.5
Momentary	27	37	9	27	0	0	5.8	3.3
Dual in-line	20	40	20	20	0	0	5.6	5.1
WIRE AND CABLE								
Coaxial	44	28	22	6	0	0	3.2	1.7
Flat ribbon	53	37	10	0	0	0	1.6	1.4
Multiconductor	26	58	16	0	0	0	2.4	2.6
Hookup	42	50	8	0	0	0	1.7	1.1
Wire wrap	42	33	25	0	0	0	2.7	1.7
Power cords	27	53	13	7	0	0	3.2	2.5
Other	40	40	20	0	0	0	2.4	6.0
POWER SUPPLIES								
Switching	0	40	33	20	7	0	8.4	7.0
Linear	0	27	55	9	9	0	8.7	6.9
CIRCUIT BREAKERS	0	27	55	18	0	0	7.8	7.7
HEAT SINKS	19	25	44	12	0	0	6.0	4.2

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	25	30	35	10	0	0	5.0	3.4
PC board	7	33	33	27	0	0	7.6	4.4
Dry reed	0	33	67	0	0	0	6.0	6.3
Mercury	0	33	50	0	17	0	9.0	7.0
Solid state	8	34	25	25	8	0	8.8	6.8
DISCRETE SEMICONDUCTORS								
Diode	17	26	52	5	0	0	5.5	4.6
Zener	24	32	36	8	0	0	4.8	4.6
Thyristor	11	39	33	17	0	0	6.1	5.0
Small signal transistor	18	32	36	14	0	0	5.7	5.6
FET, MOS	0	0	55	36	9	0	12.6	8.4
Power, bipolar	14	29	29	21	7	0	8.1	7.2
INTEGRATED CIRCUITS, DIGITAL								
CMOS	19	24	33	19	5	0	7.4	6.7
TTL	18	24	23	29	6	0	9.0	7.2
LS	13	33	20	27	7	0	8.3	7.8
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	9	9	55	18	9	0	9.8	6.2
OP amplifier	13	25	37	19	6	0	8.1	7.9
Voltage regulator	24	23	29	18	6	0	7.2	6.9
MEMORY CIRCUITS								
RAM 16k	17	33	8	42	0	0	8.0	4.0
RAM 64k	17	42	16	25	0	0	6.2	3.0
RAM 256k	13	38	12	37	0	0	7.8	3.3
ROM/PROM	23	33	11	22	11	0	8.0	4.0
EPROM	17	50	8	17	8	0	6.5	5.2
EEPROM	14	43	0	29	14	0	9.1	6.2
DISPLAYS								
Panel meters	10	40	40	10	0	0	5.6	6.0
Fluorescent	0	25	75	0	0	0	6.5	8.0
Incandescent	0	40	60	0	0	0	5.6	5.7
LED	15	30	40	15	0	0	6.2	5.2
Liquid crystal	0	17	67	16	0	0	8.3	9.3
MICROPROCESSOR ICs								
8-bit	6	44	31	19	0	0	6.4	5.5
16-bit	0	12	38	50	0	0	11.3	7.2
FUNCTION PACKAGES								
Amplifier	18	18	55	9	0	0	6.2	6.3
Converter, analog to digital	0	40	40	20	0	0	7.2	9.1
Converter, digital to analog	0	30	40	30	0	0	8.6	8.5
LINE FILTERS	10	10	70	10	0	0	7.4	7.5
CAPACITORS								
Ceramic	28	36	32	4	0	0	3.9	4.2
Ceramic monolithic	17	44	33	6	0	0	4.4	3.7
Ceramic disc	18	47	29	6	0	0	4.2	5.1
Film	17	28	39	16	0	0	6.3	4.9
Electrolytic	23	27	32	18	0	0	6.0	4.6
Tantalum	9	35	43	13	0	0	6.2	6.9
INDUCTORS	9	46	36	9	0	0	5.3	5.0

Source: *Electronics Purchasing* magazine's electronics business survey

POWER SUPPLIES



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CIRCLE NO 193

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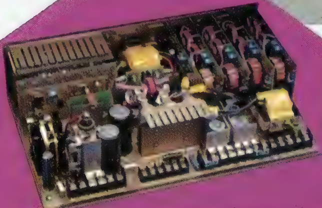

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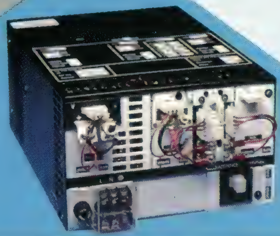

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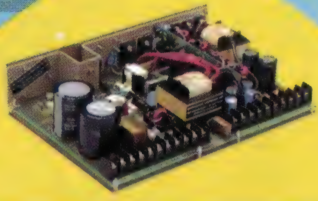

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CIRCLE NO 196

High-frequency off-line switching power supplies

Today's faster switching circuitry allows manufacturers to build smaller off-line switching power supplies. The smaller the supply, however, the greater its potential for internal heating and safety problems. Manufacturers avoid these potential problems by employing innovative thermal designs and packaging methods.

Chris Everett, *Western Editor*

This year, you'll be able to put smaller power supplies into your designs without sacrificing power. As quickly as component manufacturers introduce faster switching transistors, diodes, and other components, power-supply manufacturers are incorporating them into off-line power supplies. Because these newer supplies operate at higher switching frequencies—50 kHz and higher—manufacturers can use smaller capacitive and inductive components, thereby reducing the supplies' package sizes and increasing their power densities. In the last year, off-line switchers' power densities have increased from less than 1W/in^3 to more than 4W/in^3.

To solve the heat-dissipation problems that accompany this reduction in package size, companies are using new materials, components, and component-packaging techniques. In its MDT-400 Series, for instance, Todd Products uses both a higher switching frequency and surface-mount components to produce smaller power supplies than its earlier products. The 400W units come in a 144-in^3 package.

The MDT-400 Series includes models having a 50 to 60A, 5V primary output with ±1% line and load regulation. You can choose a 12V or 24V secondary output to power disk drives or tape drives. You can also select 5V, 12V, or 24V floating auxiliary outputs.

The MDT-400 supplies, which typically operate with 75% efficiency, use bipolar transistors that switch at 60 kHz. Although they don't switch as fast as MOSFETs do, bipolar transistors are 50 to 80% less expensive than are MOSFETs with comparable ratings, and bipolars can handle higher power requirements.

Summit Electronics also employs bipolar switching transistors in its supplies. The firm's 750W switcher, which operates at 50 kHz, has five outputs and a power density of 3.2W/in^3. The company's GX500, also a 5-output supply, is a 500W switcher in a 1-piece extended chassis. At 10×5×2.75 in., the supply is smaller than many 200W power supplies. Its primary 5V output is rated at 75A.

You can select either ±12 or ±15V each for the high-power auxiliary outputs. The low-power auxiliary outputs are set at the factory at +24 and −5V, but you can adjust them to any value between 2 and 48V. The GX500 includes an EMI filter, an ac fan output, an ac power-fail indicator, and a remote sense for the primary 5V output. The company expects qualification testing for UL, CSA, and VDE safety requirements to be complete this spring.

Some manufacturers are building smaller supplies by using MOSFET switching transistors, which can switch at higher frequencies than can bipolars. At present, some MOSFETs can operate to 1 GHz. These high frequencies let you use smaller filters to limit the EMI emitted from the input of the power supply.

Further, when a supply's operating frequency doubles, the volume necessary for its capacitive and inductive energy-storage elements is cut in half. CEI Corp, for example, reduced the size of the magnetics in its 100-kHz switching power supplies by 50%. CEI's 150W Model XL150 quad-output switcher has a power density of over 2W/in^3. The single-output model in the 250W XL250 Series has a power-density rating of 3.2W/in^3 and comes in an 8.5×4.6×2-in. package.

The company's quad switchers are available with full regulation on each of the four outputs. The 5V primary output holds load regulation to within ±1%. Cross-regulation, which is needed to limit load interaction during disk-drive start-up, for example, is held to a maximum of 0.5%.

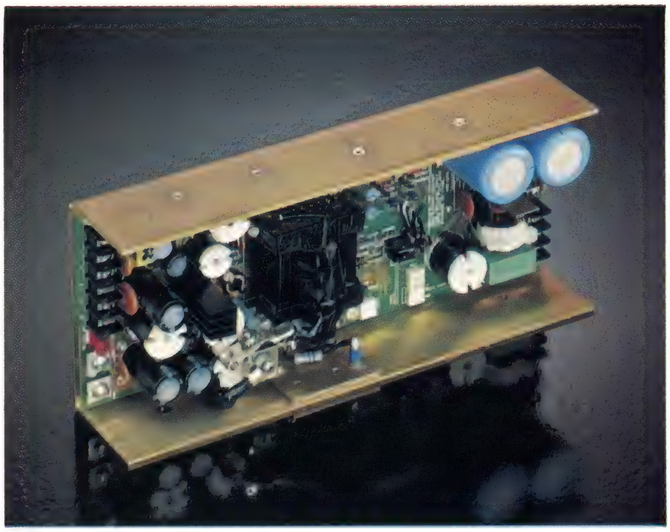
CEI uses its own low-dropout regulator-circuitry design. This high-efficiency regulator circuit provides full regulation while allowing the power supplies to retain 70 to 80% efficiency levels.

The auxiliary outputs offer true current-foldback overload protection. Under a short-circuit condition, not only will the power supply's output voltage drop, but the output current will be reduced proportionately. The supply uses a single-ended forward converter design. You can change the individual output to meet your needs by replacing just a few components. You can also adjust the current-foldback points individually on each high-current output.

Other standard features of CEI's 100-kHz switchers include dynamic inrush protection, a built-in line filter (FCC class A), remote sensing on the 5V primary output, and horizontal or vertical heat-sink fins. Op-

***A 200-kHz switching frequency** allows a state-of-the-art switching power supply to speed past its low-frequency predecessor. Today's high-frequency switchers not only offer higher performance, they also take up less space in your equipment. (Photo courtesy Sierracin/Power Systems)*

Companies are using new materials, components, and component-packaging techniques to solve the heat-dissipation problems in small power-supply packages.



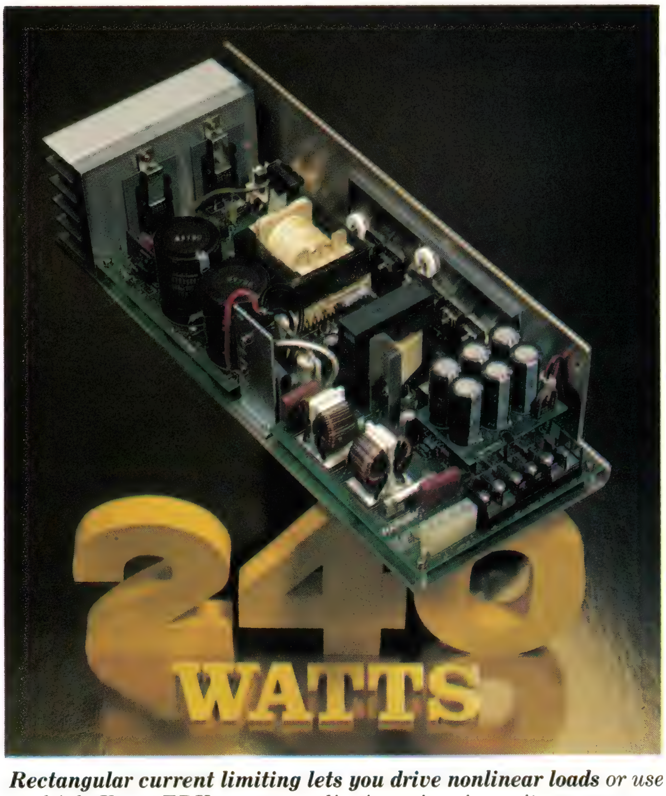
To put its 400W, 60-kHz open-frame supplies into a 144-in^3 package, *Todd Products mounts components in surface-mount packages on the underside of the pc board.*

tionally, you can add ac-okay and power-fail signals to the supplies.

Because MOSFETs use simpler external drive circuitry, the calculated MTBF figure for power supplies incorporating them is higher than that for supplies incorporating bipolars. Note, however, that a high calculated MTBF doesn't necessarily indicate a high actual MTBF. MIL-STD-217 MTBF calculations, for instance, are heavily weighted by the number of parts in a system.

Further, MOSFETs have proven to be more reliable than the older bipolar devices in power-supply designs. But it's not certain whether MOSFETs are intrinsically more reliable than bipolars, or whether MOSFET devices are more reliable because they're made in newer production facilities and with newer processing techniques. Bipolar-device manufacturers are currently upgrading their production facilities and processes; it remains to be seen whether MOSFETs will prove to be more reliable than new bipolar devices.

Most of the switching power supplies using high-frequency architectures are low- to medium-power, open-frame products geared for the high-volume computer industry. However, these supplies are not the only ones that realize the benefits of high-frequency MOSFET-based designs. For example, HC Power offers the HC Series 500 to 1500W single- and multiple-output supplies in industry-standard (5×8-in.) packages. Supplies in the HC Series include single-output units rated from 2V to 48V at 11A to 340A. Dual-, triple-, quad-, and penta-output supplies have primary outputs of 5V at as much as 230A.



Rectangular current limiting lets you drive nonlinear loads *or use multiple Kepco ERX power supplies in series. A monitor warns you of ac power loss within a half cycle, so you typically have 30 msec to shut down your system.*

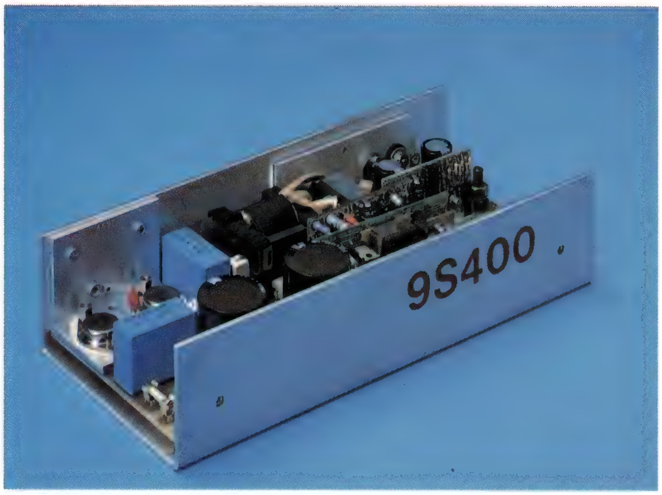
You can order secondary outputs of 2V to 48V at 6A to 30A and auxiliary outputs of 2V to 48V at 2A to 10A. The fifth output on the penta-output supply is available as a 12V or 24V disk-drive supply. It provides continuous current ratings of 5A to 10A and peak loading current of 8A to 15A.

Instead of using the more popular voltage-mode control in its switchers, HC uses current-mode control. Both control schemes are based on feeding an error voltage back to one of the comparator's two inputs. In the voltage-mode control circuit, a fixed oscillator is connected to the second comparator input. In the current-mode control circuit, a voltage that's proportional to the output current is fed to the second input.

Current-mode control offers several advantages over voltage-mode control. First, a power supply that uses current-mode control can react more quickly to input voltage changes. In such a power supply, the drive logic monitors each switching-transistor pulse. In comparison, a voltage-mode unit can take five to 10 cycles

before responding to an input change. The current-mode-control supply, therefore, instantaneously rejects input-voltage transients and noise, which are the primary causes of switching-element failures in power supplies. Current-mode-control supplies also exhibit better transient response to large step-load changes than do voltage-mode supplies. For the HC Series, this transient response is typically less than 50 μsec. In comparison, voltage-mode supplies typically respond in 100 to 150 msec.

Because current-mode-control supplies monitor output current, you can connect them in parallel without having to match their output voltages precisely. Further, when you're using the supplies in redundant-operation modes, you don't have to match load cables to compensate for IR drop. In a current-mode-control design, the paralleled outputs are forced to share current to within 1%. The HC devices incorporate a current monitor, which provides a calibrated voltage proportional to the output current. Other logic and control functions in the supplies include a remote sense, power-fail warning, and remote margin control.



Transient-response characteristics approaching those of linear power supplies *and low conducted EMI are two results of the harmonic-resonant design of Sierracin/Power Systems' 400W switcher. Switching at 200 kHz, the supply offers a 2.9W/in³ power density.*

High-frequency switching has some drawbacks

Although supplies that switch at high speeds can use smaller inductive and capacitive components, they also experience increased power losses in choke and transformer cores. To solve this problem, Kepco/TDK uses a new ferrite material, H7C4, in all of its Series RBX chokes and transformers. H7C4 has lower loss-vs-frequency and loss-vs-temperature characteristics than do many other materials. High switching frequencies also cause power losses in the transformers' copper windings because of skin effect. To reduce these losses, Kepco uses Litz-type stranded wire in its transformers.

Another manufacturer, Theta-J, experienced a similar problem when it increased the switching frequency of its 50W supply to 350 kHz and the frequency of its 100W unit to more than 750 kHz. To minimize power losses caused by interwinding capacitive variations and skin losses, Theta-J uses smaller inductive components with fewer turns. The 5V transformer, for example, uses a 1-turn secondary.

High-frequency switching also reduces the filtering efficiencies of the capacitors in a power supply's output filters. To counter this problem, Kepco/TDK stacks the filter capacitors on both sides of the forward converter's output choke, thus minimizing the capacitors' inherent equivalent series inductance and resistance and improving efficiencies (**Fig 1**).

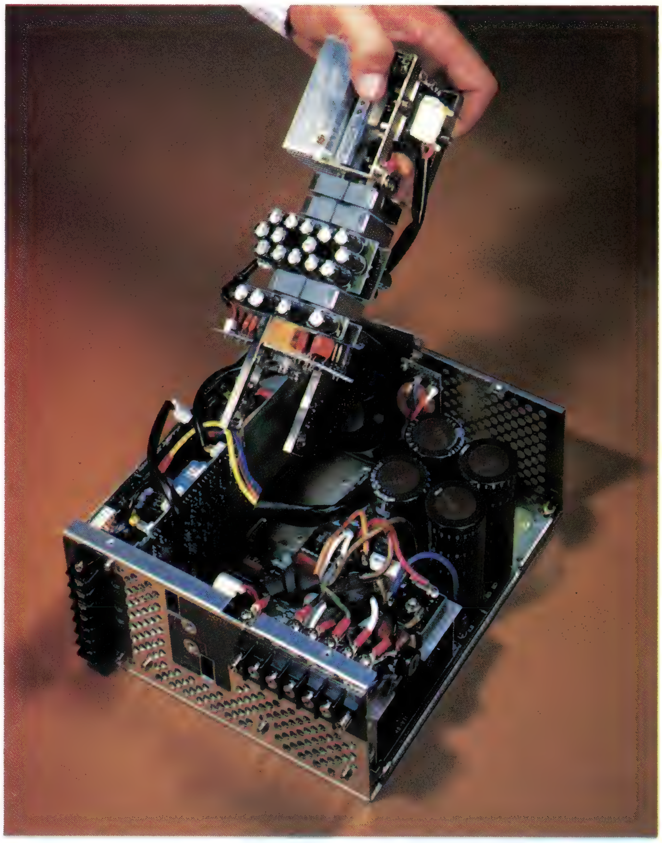
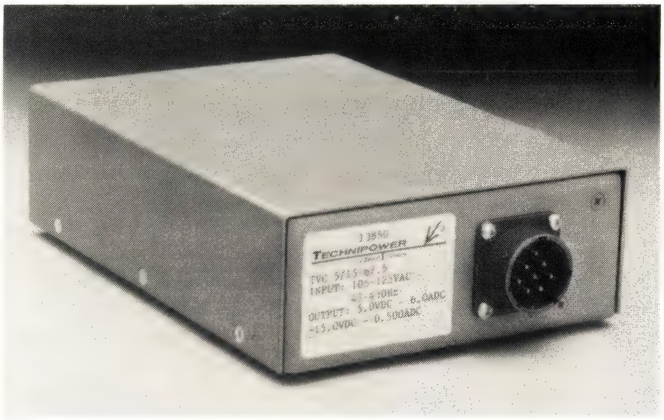


Fig 1—To reduce high-frequency filter-efficiency losses *in its RBX power supplies, Kepco stacks as many as 39 filter capacitors on either side of the forward converter's output choke.*

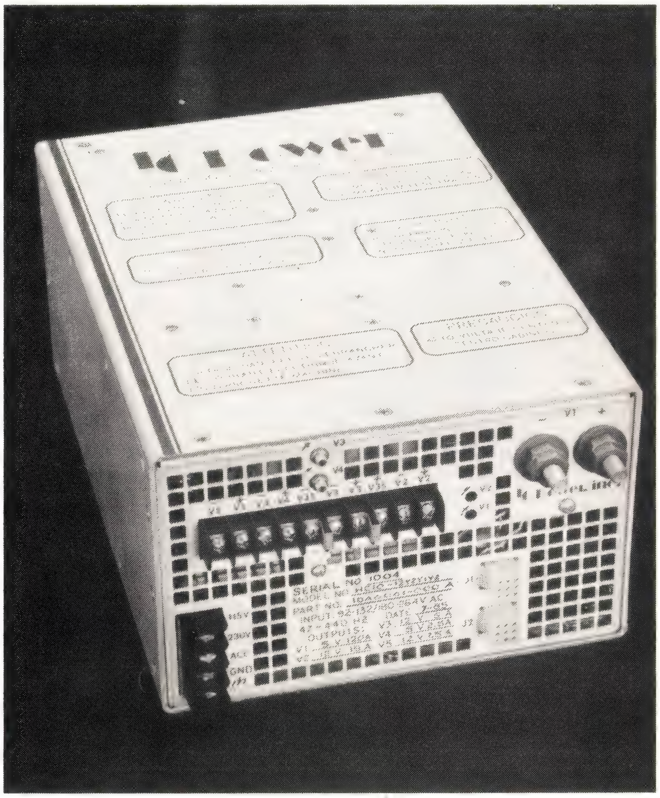
When a supply's operating frequency doubles, the volume necessary for its capacitive and inductive energy-storage elements is cut in half.

In addition, high frequencies cause inefficiency in switching transistors. In nonzero-current-switchers, current flowing through the switching transistor during turn-on and turn-off generates losses. As the operating frequency increases, a higher proportion of the energy flowing through the switching transistor is lost as heat. Theta-J solves this problem by employing a zero-current resonant-mode switching scheme in its supplies. By controlling the time that the resonant primary circuit can transfer energy to the secondary circuit, the zero-current resonant switching scheme forces the current to zero at the switching transition time, thereby reducing switching losses.

Besides using smaller inductive components in its high-frequency supplies, Theta-J reduced the size of some of the control circuitry in its supplies. The company uses a power-monitor IC and a driver IC to ensure repeatable control and operation of its supplies from unit to unit. The power-monitor IC includes a custom high-voltage circuit, and the driver IC controls the MOSFET switching circuitry. The MOSFET switching transistors are packaged with other circuitry in a custom power hybrid with both primary and secondary side functions.



Designed to meet the reliability guidelines of the Navy's NAV/MAT P-4855, *these Technipower triple-output supplies can operate in harsh environments under moderate shock conditions.*



The current-mode switching technology of this 5-output 1000W supply *from HC Power improves the supply's transient response to large step changes. The switcher's outputs return to steady state within 50 μsec.*

Of course, high-frequency switching also causes noise problems. One manufacturer, Sierracin/Power Systems, reduces noise in its 200-kHz supplies by using a proprietary harmonic-resonant design. The company's 9S400 single-output supplies are rated at 400W (2.9W/in^3).

The harmonic-resonant design closely resembles a half-bridge design whose MOSFET switching transistors operate at 200 kHz. The resonant circuit includes an inductor in the primary and a resonating capacitor in the secondary. The resonant circuit oscillates at 1.2 MHz. Because the resulting waveform is sinusoidal, the circuit generates very little switching noise, so the 9S400 switchers meet the conducted-noise requirements of both FCC Docket 20780 level B and VDE 0871 level B regulations, including the recent modifications that restrict noise above 10 kHz. The 9S400's transient-response characteristics (±2% deviation for a 75% to 100% to 75% step-load change with recovery in 100 μsec) approach those of linear supplies.

Both the HC Power and Sierracin power supplies shut down automatically when their internal-temperature safety limits are exceeded. To operate at full load, the Sierracin 9S400 requires additional cooling either through conduction or forced air.

New thermal designs counter heat troubles

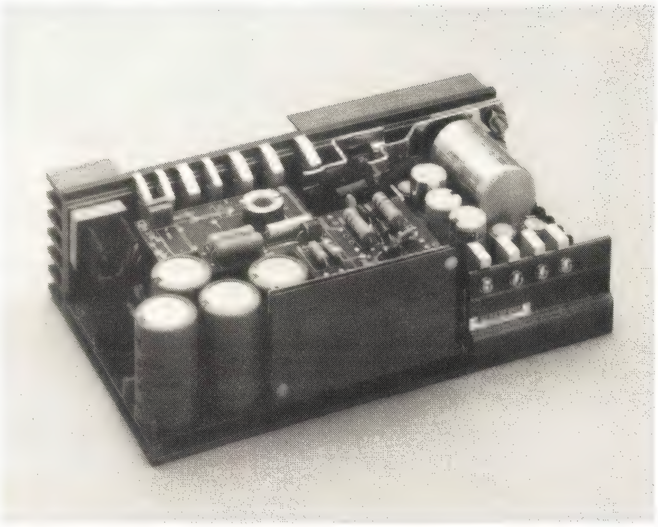
Kepco/TDK uses built-in fans to cool its RBX Series supplies. If the fan fails, a monitor circuit inhibits the power-MOSFET drive and turns the output off. The

RBX switchers are 600W single-output units. They're available with 2V, 5V, or 24V outputs, and their operating efficiencies range from 65% (for the 2V model) to 85% (for the 24V model).

Theta-J's 50W and 100W supplies both feature 4.5W/in^3 power densities. To counter the internal heating problems associated with such a high density, the company uses a common-surface thermal design that eliminates the use of individual heat sinks. In the design, all the dissipative components (the dissipative core materials, the primary-side power switch module, and the secondary rectifiers) are attached to a metal baseplate through selected heat-resistant insulators. All other components that must be kept cool are mounted so that they have maximum thermal resistance to the baseplate and minimum thermal resistance to the ambient.

Theta-J's power supplies represent the highest frequency off-line switchers. You can, however, use dc/dc modules such as Vicor's (Andover, MA) VI-100 models to build off-line switching supplies that operate at higher frequencies. (See **box,** "Use dc/dc modules to build an off-line power supply.")

You can choose a 75W module with a 5V output, or you can select one of four 100W modules with either a 12V, 15V, 24V, or 48V output. For more power, you can add booster modules. Each booster module doubles the power of its master. You can add as many boosters as you need to reach the power level you desire or to build system redundancy into your design.



At 10×5×2.75 in., this 500W power supply *from Summit Electronics is smaller than many 200W power supplies. It offers a power density of 3.6W/in³.*

The Vicor switching modules are based on a 1-MHz, zero-current-switching forward-converter topology. Unlike Theta-J, Vicor doesn't use a resonant scheme to zero the current at the power transistors' switching times. The modules feature power densities of 13 to 51W/in^3 and good dynamic-load-regulation characteristics. The output voltage returns to within 1% of steady state within 100 μsec after a 10% to 100% load change.

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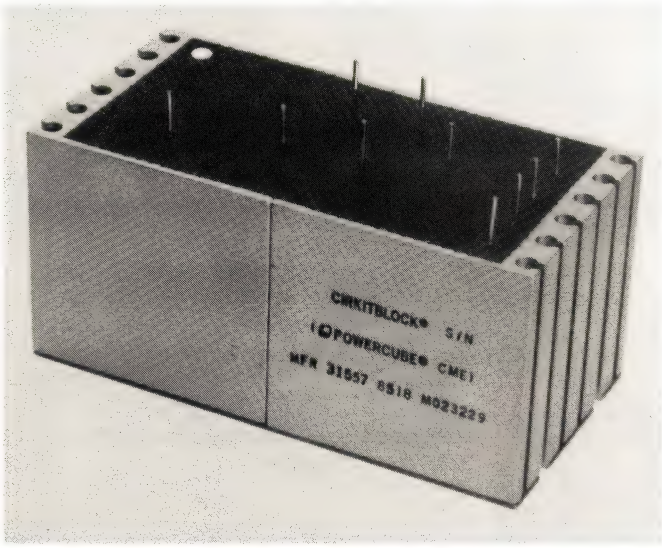
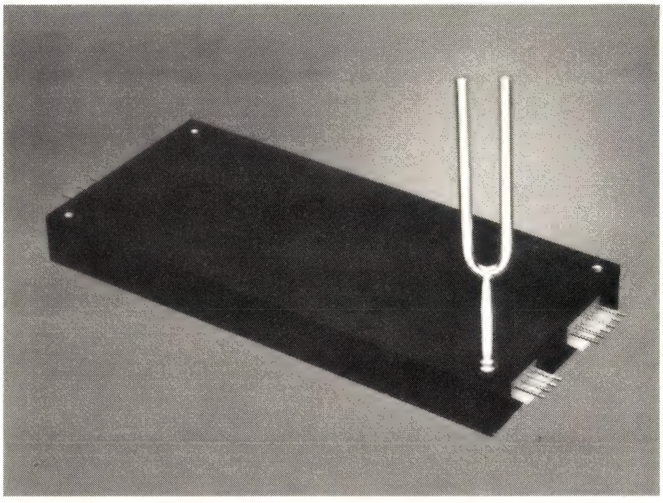


You provide the rectified ac input to generate a 50W, 5V output *from Powercube's Icecube. To obtain more power, you can connect two or more Icecubes in parallel.*



Operating to more than 750 kHz, this 100W switcher, *the Q100ADAD from Theta-J, achieves a power density of 4.5W/in³. To counter the internal heating problems associated with such a high density, the company uses a common-surface thermal design that eliminates the use of individual heat sinks.*

Use dc/dc modules to build an off-line power supply

Steven D Cogger, *Vicor Corp*

Until recently, when you needed a power supply with more +5V power than a power-supply manufacturer offered or when you needed a voltage other than the standard ±5 or ±12V, you either had to buy a special power supply (by paying a nonrecurring engineering charge and making a volume commitment) or you had to design your own supply. Now, however, you have a third option: You can use dc/dc modules to design your own supply.

All off-line switching power supplies are dc/dc converters with ac-to-dc conversion circuitry on the front end. Designing your own power supply with dc/dc converter modules (such as Vicor's 1-MHz modules) is an easy task. Your main task is to design the ac-to-dc front end and select heat-sink components. By using modules with high power densities, you can design power supplies having energy densities of 3.9W/in^3 without using surface-mount devices or special manufacturing techniques.

For example, assume you need a supply with outputs of +5V at 15A, +12V at 7A, and −12V at 5A. You can configure this supply with a Model V1-160 and two Model V1-161 modules from Vicor. The outputs are isolated, so you can obtain positive and negative outputs by wiring the modules' outputs as shown in **Fig A.**

First, you calculate the total output power of the supply by adding the output power from each module. The total output of the modules in this example is 219W. The total power required from the ac-to-dc rectifier is the total output power divided by the efficiency of the modules. The modules employ a zero-current-switching topology, so their minimum efficiency is 80%. The total input power required is 219W÷0.8, or 273.75W.

Next, you calculate the input current to determine the value of filter capacitors C_4 and C_5. This calculation is the total input power, 273.75W, divided by the nominal line voltage. Because the front end is a voltage doubler, comprising C_4, C_5, and a full-wave bridge (B), the voltage is 2(115×1.4) or 320V dc. The power supply's nominal input current is 0.86A. You calculate the value of the capacitors by using this equation c=it÷V, where i is the nominal input current, t=8.33 msec for a 60-Hz

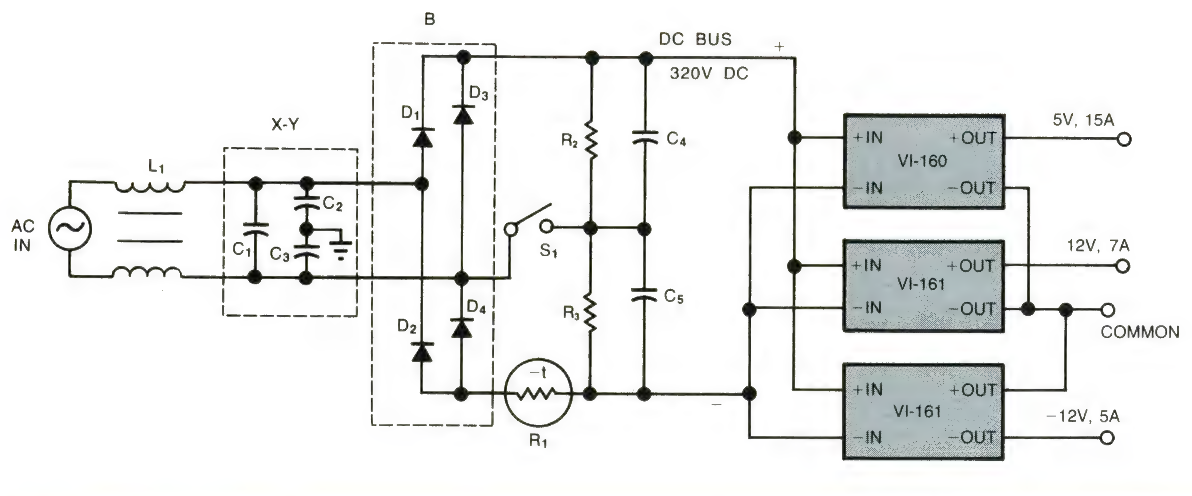


***Fig A—The circuitry you add** to Vicor's VI-160/161 dc/dc modules provides the ac/dc conversion, filtering, and in-rush current-limiting functions of a high-frequency off-line switcher.*

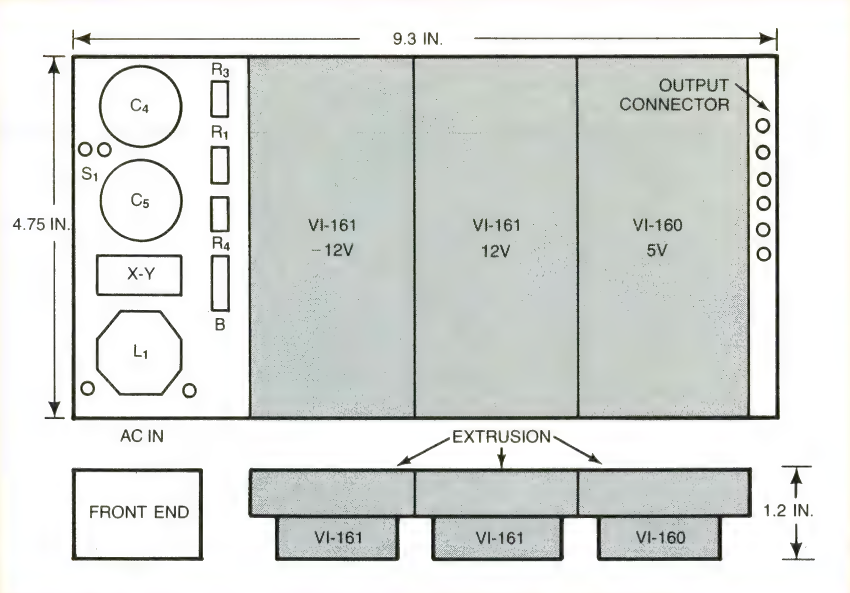


Fig B—To dissipate heat from your 3.9W/in³ power-supply design, *you should select an extrusion that has a thermal resistance to air of about 2.4°C/W.*

line, and V is 30V (a design parameter of the modules).

The total capacitor value is 237 μF. Because the input is a voltage doubler and the capacitors are in series, you multiply the total input capacitance by 2 and choose the closest standard value. In this design, C_4 and C_5 must be 470-μF, 200V capacitors.

The negative-temperature-coefficient (NTC) thermistor (R_1) limits inrush current. For this design, R_1's cold value is 10Ω, which limits the turn-on surge current to 32A on the first cycle. The rectifiers, D_1 through D_4, must handle the peak inrush current and the peak current needed to charge the filter capacitors every cycle. A safe design value for the diode current rating is five times the steady-state dc current. This design uses 5A diodes. You can buy a full-wave bridge in a single assembly instead of using four separate diodes.

To meet VDE and FCC noise specifications, you need the input filter, which comprises L_1 and C_1, C_2, and C_3 (the X-Y assembly). Because the modules' operating frequency is so high, the filter elements are much smaller than those required for a 20-kHz power supply. When you lay out the front end, be sure to observe UL and VDE spacing requirements.

Finally, the design requires heat sinking. Overall conversion efficiency is an important factor in heat-sink calculation. Consider two 100W supplies, one with 70% efficiency, the other with 80% efficiency. The supply with 70% efficiency dissipates 42.9W, the one with 80% efficiency dissipates 25W, for a difference of 17.9W. Although this difference doesn't seem large, it represents an extra 35.8°C in a 2°C/W heat sink.

You can mount the modules in any direction. In some cases, you can mount the modules on an inner wall or on a baffle in your system. If you use an inner wall, the heat sink will essentially be free and will require no extra power-supply volume. Assuming the ambient air temperature is 40°C max, and the air is not moving, each module will require a heat sink to keep its baseplate temperature below 85°C.

The module that provides 12V at 7A can operate at 82% efficiency, so it will dissipate 18.4W at full load. You should choose a heat sink with a thermal resistance to air of about 2.4°C/W or less. A common extrusion that's 4.56 in. long and 0.750 in. high with 19 fins on 0.250-in. centers has a thermal resistance of 2.0°C/W and is a good choice for this application. You can use the same extrusion on all modules.

Fig B shows the space that your power-supply components will require. All parts shown are available from stock. The volume of the package is 53.89 in^3, so its power density is 3.9W/in^3.

The author is an applications engineer for the Andover, MA, firm.

A high calculated MTBF doesn't necessarily indicate a high actual MTBF. Often, the calculations are heavily weighted by the number of parts in a system.

The calculated MTBF for the modules is 214,000 hours. This high calculated value is due in part to the low parts count (less than 50) and the lack of aluminum electrolytic capacitors in the Vicor design.

Powercube (Billerica, MA) also offers high-frequency dc-input modules to which you supply a rectified input. The 4×2×1.9-in. 50W model costs \$880; the 7.5×4.9×7.8-in. 500W version costs \$3750. Both enclosed models furnish a single 5V output (line and load regulation each spec at ±0.5%) and employ MOS transistors that switch at 100 kHz. The supplies meet MIL-STD-461. (Several companies offer high-frequency dc/dc switchers that accept low-voltage inputs; see, for example, pg 118.)

Check regulations when choosing supplies

When you're choosing a power supply for your system, don't overlook the safety regulations that will apply to your product. If you want to sell your system abroad, for example, you'll have to have it certified to international regulations, so the power supply you choose must be able to meet these regulations.

Because safety regulations limit the space between components in a supply, manufacturers of these smaller supplies will find it harder to certify their products. Keep the applicable regulations in mind when you specify one of these supplies.

Currently, more than 25 national and multinational agencies exist to decide whether your products can be sold within their countries or areas of influence. The most familiar agencies are Underwriters Laboratories in the US, Canadian Standards Association in Canada, and Verband Deutscher Electrotechniker (VDE) in Germany.

In many countries, you're not permitted to sell your products unless they meet the requirements of a specific standard or standards. For example, Telecom equipment attached to the British phone system must meet the requirements of the British Telecom (formerly British Post Office) Technical Guide No 26. Telecom and

External power supplies

Bob Marks, *Ault Inc*

For designs requiring 100W or less, you needn't resort to a compact high-frequency switching power supply in order to accommodate limited space requirements within your equipment; an external switching power supply can be a cost-effective alternative. External supplies are especially suitable for powering computer peripherals, disk drives, CRT displays, microprocessors, telephone key sets, multiplexers, modems, and other data-communications equipment.

External power supplies offer several advantages over internal supplies. First, they save you the time and trouble of designing an internal power source. They'll also save space in your system, so you can either reduce the size of your design or add extra features. And because an external supply won't contribute to heat buildup inside your design, your system will undergo less stress during operation, so it may achieve a higher MTBF. You may be able to eliminate fans and even vents from your system. Finally, if your external supply ever fails in the field, you can simply unplug it and plug in a new one.

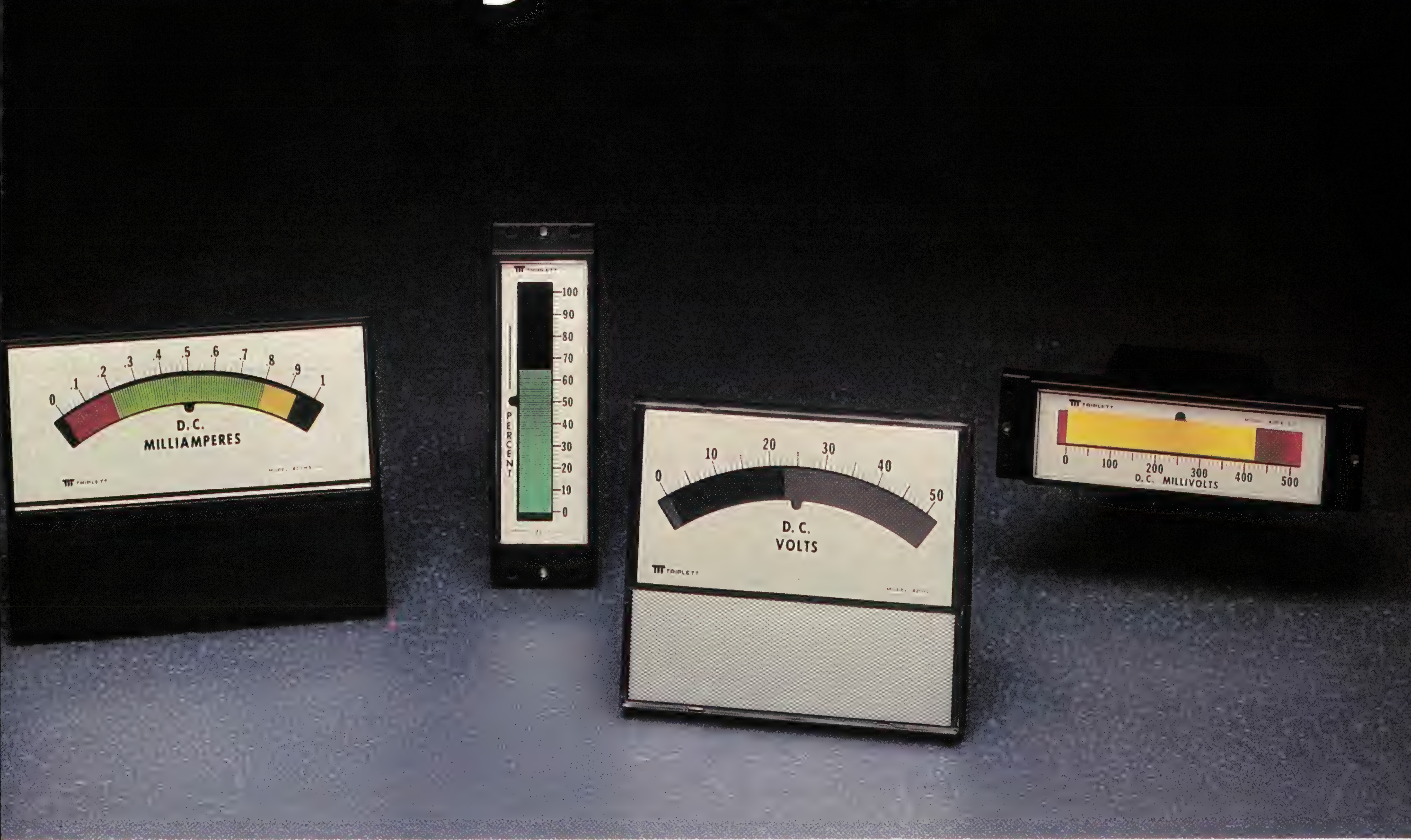
Currently, triple-output external switchers can deliver as much as 50W; 100W units are still under development. External supplies come in two basic styles. The smaller, lower-power units plug directly into ac wall outlets. Higher-power switchers plug into the ac outlet via a line cord and sit out of the way on a desktop or the floor.

External switching power supplies typically employ either off-line or secondary switching. Off-line switching is suitable for systems requiring high power and performance. Less-expensive secondary switchers provide lower power levels.

External switching power supplies come in a range of outputs and case sizes. For example, Ault's off-line switchers supply either 25 or 50W and come in 6.5×3.75×2.25-in. cases; they cost less than \$90. The company's secondary switchers are rated at about 16W and come in 4.7×2.7×2.2-in. cases. The supplies use surface-mount components.

The author is director of design engineering for the Minneapolis, MN, firm.

Eye-Tech



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Colorful, back-lit displays are available in red, green, amber or blue. You may also choose any combination of these colors. Black on gray is standard.

Adaptable. Panel meters are available in the ''G'' Series curved display; the ''WS'' Series curved display and in the Edgewise Series, vertical or horizontal with a front or rear mount.

When you are looking for the finest in high-tech panel instrumentation, look to Triplett, the Company America has trusted for more than 80 years.

For more information, call 1-800-TRI-PLET ext. 40.

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Some manufacturers are building smaller supplies by using MOSFET switching transistors, which can switch at higher frequencies than can bipolars.

data-processing equipment sold in Germany must be designed and built to VDE 0804/3.77 standards.

In some countries, power supplies must be certified twice. First they must meet the requirements of the standard for power supplies, and then they must meet the standard for the product in which the power supply will be used. In the US, a power supply must first meet the requirements of UL standard 1012 for power supplies. Then, depending on the system the supply is designed for, the supply might have to meet UL 114 (for electronic office appliances and business machines), UL 478 (for electronic data-processing units and systems), or UL 508 (for electric industrial-control equipment). In Canada, power supplies must meet the requirements of CSA standard C22.2, No 107-1957, which governs rectifying equipment, as well as requirements governing the end product.

It takes from six to eight weeks to have a power supply tested and recognized by UL. VDE certification could take as long as a year. It's a good idea, then, to find out during your design stage which standards will apply to your product and plan to have the required certification testing performed. You can, however, shorten the German certification process by using the TUV-Rheinland testing agency; its US office is located at 50 Main St, Mount Kisco, NY, 10549; phone (914) 241-2400.

Further, when you select a power supply, you must know whether the supply is actually certified to the necessary standards or whether it's only designed to meet the requirements of specific standards. For example, NCR Power Systems' supplies are UL recognized, VDE approved through testing by TUV, CSA certified and compliant with IEC 380 (IEC does not have a certification program). ACDC's RH Series supplies are UL recognized and CSA certified. The company's Model RH101 is a 100W single-output open-frame supply operating at 100 kHz. Before being shipped, all RH101 supplies are burned in for 24 hours with ac cycling and then computer tested. Test results are shipped with each unit.

Panasonic's 75W MR Series and 100W MS Series

Manufacturers of high-frequency off-line switching power supplies

For more information on high-frequency switching off-line power supplies, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Abbott Transistor Laboratories Inc
Power Supply Div
5200 W Jefferson Blvd
Los Angeles, CA 90016
(213) 936-8185
Circle No 676

ACDC Electronics
401 Jones Rd
Oceanside, CA 92054
(619) 757-1880
Circle No 677

CEI Corp
Box 501
Londonderry, NH 03053
(603) 623-8888
Circle No 678

Deltron Inc
Box 1369, Wissahickon Ave
North Wales, PA 19454
(215) 699-9261
Circle No 679

Energetic Systems Inc
130 E St Charles Rd
Carol Stream, IL 60188
(312) 653-1920
Circle No 680

HC Power Inc
1571 Parkway Loop, Suite D
Tustin, CA 92680
(714) 259-0788
Circle No 681

Kepco Inc
131-38 Sanford Ave
Flushing, NY 11352
(718) 461-7000
Circle No 682

Lambda Electronics
515 Broad Hollow Rd
Melville, NY 11747
(516) 694-4200
Circle No 683

Modern Power Conversion Inc
7100 Warden Ave, Unit 3
Markham, Ontario, Canada L3R 5M7
(416) 477-3387
Circle No 684

NCR Corp
Power Systems
584 S Lake Emma Rd
Lake Mary, FL 32746
(305) 323-9250
Circle No 685

Panasonic Industrial Co
Computer Components Div
One Panasonic Way
Secaucus, NJ 07094
(201) 392-4290
Circle No 686

Qualidyne Systems Inc
3055 Del Sol Blvd
San Diego, CA 92154
(619) 575-1100
Circle No 687

RTE Power/mate
2875 S 171 St
New Berlin, WI 53151
(201) 440-3100
Circle No 688

Sierracin/Power Systems
20500 Plummer St
Chatsworth, CA 91311
(818) 998-9873
Circle No 689

Summit Electronics Inc
855 E Collins Blvd
Richardson, TX 75081
(214) 231-1456
Circle No 690

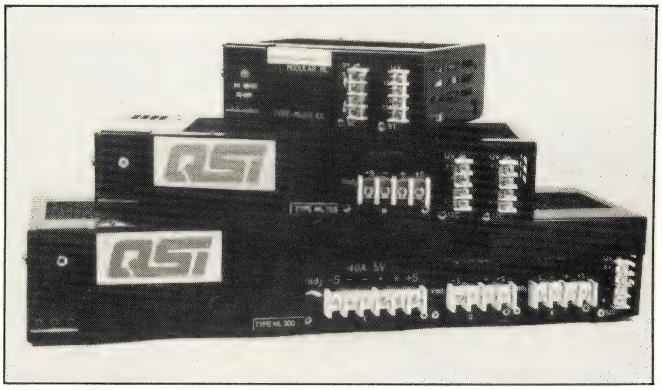
Technipower
Box 222, Commerce Park
Danbury, CT 06810
(203) 748-7001
Circle No 691

Theta-J Corp
107 Audubon Rd
Wakefield, MA 01880
(617) 246-4000
Circle No 692

Todd Products Corp
50 Emjay Blvd
Brentwood, NY 11717
(516) 231-3366
Circle No 693

Total Power International Inc
418 Bridge St
Lowell, MA 01850
(617) 453-7272
Circle No 694

Xentek
297 S Pacific St
San Marcos, CA 92069
(619) 744-3346
Circle No 695



You can build your own power supply *by selecting from Qualidyne's power modules, post regulator modules, and enclosures.*

supplies are recognized by UL, certified by CSA, and approved by TUV to VDE standards. The supplies also conform to IEC 380 and BS 5850.

Because of the long certification cycle, many power-supply manufacturers offer supplies for sale before they've been certified. Deltron's V Series is an example. The V Series is designed to meet VDE, IEC, UL, CSA, BT, ECMA (European Computer Manufacturers Association), and CEE (International Commission on Rules for the Approval of Electrical Equipment) specifications. The supplies feature 3750V ac isolation, 8-mm spacing between primaries and secondaries, 4-mm spacing between primaries and ground, and a 0.75-mA leakage current between line and ground. The manufacturer is in the process of having the supplies certified.

For supplies that the manufacturer claims are "designed to meet" a certain standard, you'll have to determine on your own whether they'll actually meet the requirements when put to the test. **EDN**

Table begins on pg 146

References

1. Pressman, A, *Switching and Linear Power Supply, Power Converter Design*, Hayden Book Co, Rochelle Park, NJ, 1977.
2. Wright, M, "Special Report: Switchers," *EDN*, May 2, 1985, pg 102.
3. *Regulatories in the Electronics Marketplace*, Sierracin/Power Systems, Chatsworth, CA, 1984.

Article Interest Quotient (Circle One)
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OUR QUARTER-POUNDER OF POWER

Military 100 Watt DC-DC Converters

- Weight: ¼ pound
- Size: 4 cubic inches
- Power: 100 Watts
- Density: 400W/lb & 25W/in^3
- Switching Frequency: 1 Megahertz

Inland Power Technology serves up state-of-the-art DC to DC converter technology. Encapsulated 4 ounce, 4 cubic inch modules that supply up to 100 Watts of low noise, tightly regulated DC power.

They're built to meet the requirements of MIL-STD-810A for shock, acceleration, vibration, altitude, humidity and salt spray. Reliability is exceptional with a calculated MTBF of over 200,000 hours at 80°C per MIL-HDBK-217D.

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We can also configure complete power systems with output powers in excess of 2KW and power densities up to 47 W/in^3. For example, a triple output system with 5V @ 105 A & ± 15V @ 6.7A has a volume of only 24 in^3 and weighs a mere 1½ lb.

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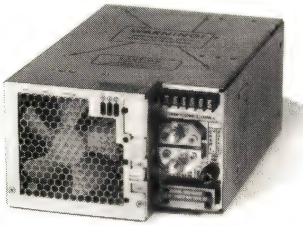
CIRCLE NO 139

How to design a power supply in 2½ minutes.

Immediate shipment on 57 standard models.

Do what IBM, Control Data, Sperry, Xerox, and AT&T do. Spin your Rolodex to "P" and phone Pioneer.

In less time than it takes for a cup of coffee, you



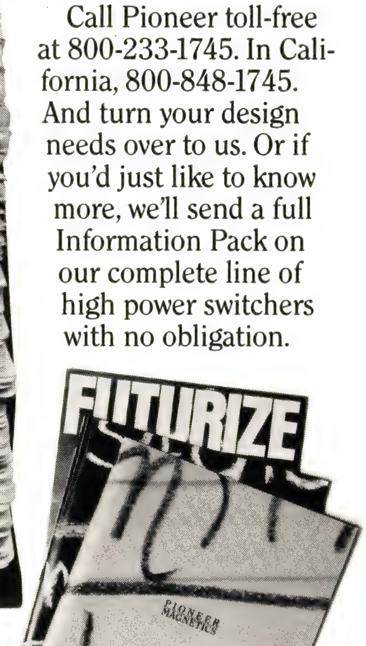
can have Number One in high power switchers working on your power supply. And you can get back to work on your system.

Pioneer starts by taking you through our QuickCheck Spec List. Is your input AC or DC? How many watts of output power—from 375 up to 2000—do you need? How many channels? What tolerances? Does your unit need to meet International EMI specs? Or International Safety specs to the SELV level? Need built-in Volatile Memory Backup (or any of three dozen other options)?

No matter how unique the specs on your unit, chances are excellent that Pioneer has built one like it—not once but many times. (We should have; we've shipped well over a quarter million units.)

So you don't have to worry about expensive one-of-a-kind pricing. Or reliability. One customer put 333 Pioneer units through a million-hour cumulative evaluation. Result: MTBF's in excess of 115,000 hours!

Call Pioneer toll-free at 800-233-1745. In California, 800-848-1745. And turn your design needs over to us. Or if you'd just like to know more, we'll send a full Information Pack on our complete line of high power switchers with no obligation.



Pioneer Magnetics. Because systems designers should design systems, not power supplies.

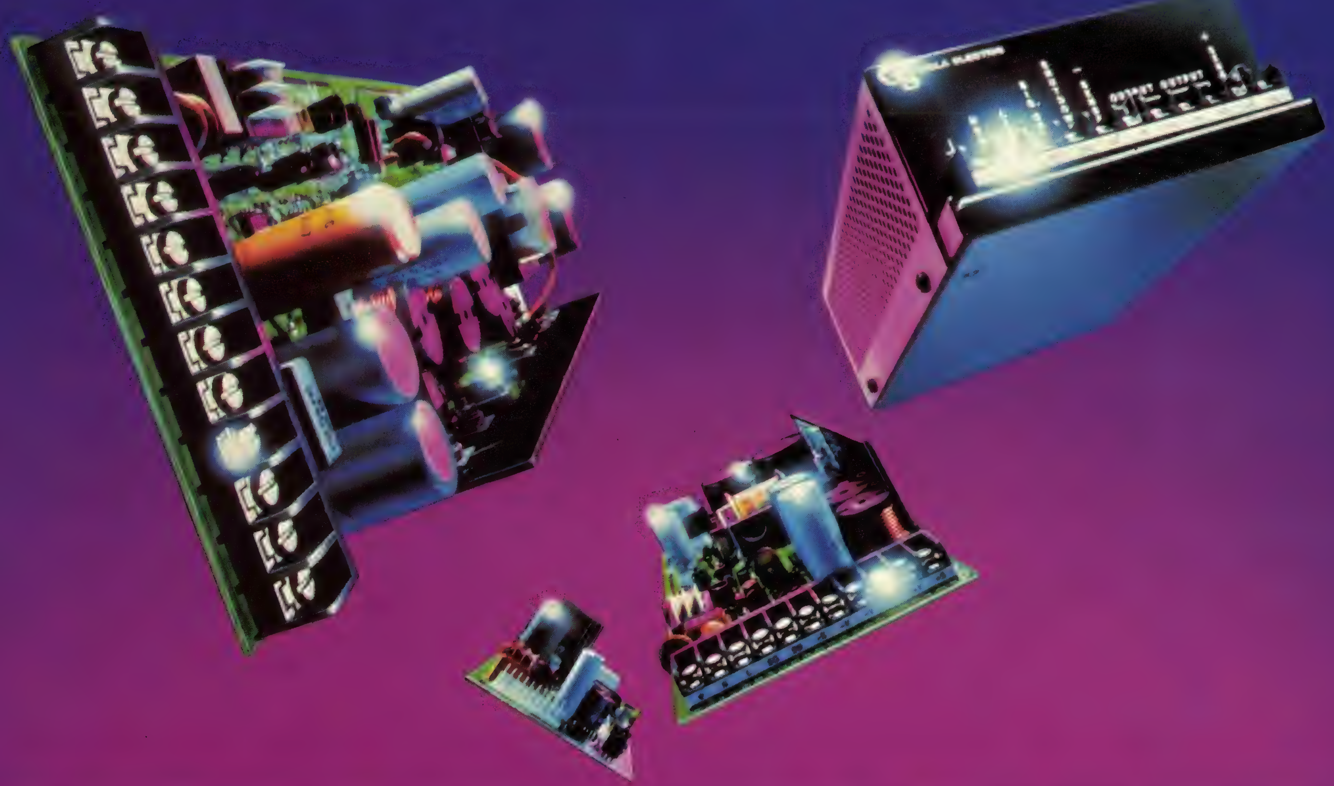
CIRCLE NO 140

REPRESENTATIVE HIGH-FREQUENCY OFF-LINE SWITCHING POWER SUPPLIES

MANUFACTURER	MODEL NUMBER	OUTPUT POWER (W)	OUTPUT VOLTAGES (V)	ENCLOSED (E) OPEN FRAME (O)	DIMENSIONS (IN.)	POWER DENSITY (W/IN.)	EFFICIENCY (%)
ABBOTT	MB100T	100	5, ±12; 5, ±15	E	1.875 × 3.5 × 7.5	2.0	65
ACDC	RH101	100	5	E	8 × 4 × 2.2	1.4	75–85
CEI	XL150	150	±5, +12; 5, ±12; 5, ±15	O	8 × 4.6 × 1.9	2.2	70–85
	XL250	250	5; 5, ±12; 5, ±12, +24; ±5, ±15	O	10 × 5 × 2.125 (MULTI-OUTPUT VERSIONS)	2.4	70–85
DELTRON	V120A	120	5	O	2.5 × 8.5 × 7	0.8	80
	V360D	360	24	O	2.5 × 10.5 × 9	1.5	80
	V500A	500	±5, ±12	O	2.75 × 13 × 11.5	1.2	80
ENERGETIC SYSTEMS	ALPHA	50	5; 12; 24	O	4 × 4 × 1.6	2.0	80
	BETA	60	24; 48	E	5.7 × 5.9 × 1.5	1.2	80
	DELTA	60	5, ±12; 5, ±15	O, E	5 × 4 × 1.5	2.0	75
HC POWER	HC15-1	1500	5	E	5 × 8 × 11.25	3.3	75
KEPCO/TDK	ERX 5-48	240	5	O	12.9 × 3.5 × 2.8	1.9	68–80
	RBX 05-120K	600	5	E	3.74 × 7.87 × 8.66	2.4	80
	RBX 24-25K	600	24	E	3.74 × 7.87 × 8.66	2.4	85
	MRM 270KV	120	+5; +12; −12; −5	O	10.5 × 5 × 2.5	0.6	75
LAMBDA	LRS-52-5	75	5	E	2 × 4.9 × 6.25	1.2	67
	LRS-56-5	450	5	E	4.4 × 4.9 × 11.5	1.8	75
MODERN POWER CONVERSION	150B/200	200	5, ±12; ±5, ±12; 5, ±12, +24; 5, ±12, +28; 5, ±12, +8	O	10 × 5 × 2.3	1.7	80
NCR	HZNNL05121205	230	5, ±12, −5	O	11.5 × 6 × 2	1.7	70
PANASONIC	ETU-5V120U	60	5	O	3.9 × 8.1 × 2.2	0.9	65
QUALIDYNE SYSTEMS	ML 100 A1	100	5	E	2.36 × 5.17 × 9.25	0.9	70–85
	ML 300 K6	300	5, ±12, +24, −5	E	3.15 × 5.17 × 15.75	1.2	70–85
RTE POWER/MATE	EV-H	200	5; 12; 15; 24	O	4.9 × 2.3 × 9	2.0	75
SIERRACIN/POWER SYSTEMS	9S300	300	5; 12; 15; 24	O	10 × 5 × 2.5	2.4	72
	9S400	400	5; 12; 15; 24	O	11 × 5 × 2.5	2.9	72
SUMMIT	GX500 5001	500	±5, ±12, +24	O	10 × 5 × 2.75	3.6	75
	GX650 5004	650	±5, ±15, +12	O	14 × 6 × 3	2.6	75
TECHNIPOWER	TVC/12-40/4.2	300	5, ±12	E	15 × 7 × 3	1.0	60–80
THETA-J	P7ADD	7.5	5, ±12	E	4.4 × 2.2 × 0.65	1.2	70
	P50ADD	50	5, ±12	E	2.8 × 5 × 0.8	4.5	80
	Q100ADAD	100	5, ±12, −5	E	3.5 × 7.8 × 0.8	4.5	80
TODD PRODUCTS	MDT-400	400	5, ±12	O	11.5 × 5 × 2.5	2.8	75
	MDX-400	400	5, ±12	O	11.5 × 5 × 2.5	2.8	75
TOTAL POWER	KSY054506	1000	5	O	5 × 13.4 × 12.6	2.7	70

OUTPUT RIPPLE/NOISE	LINE REGULATION	LOAD REGULATION	BIPOLAR (BI) OR MOSFET (MOS)	SWITCHING FREQUENCY (kHz)	SAFETY AND EMISSIONS STANDARDS MET	PRICE (QUANTITY)	COMMENTS
100 mV p-p	10 mV	10 mV	MOS	200	MIL-STD-461B, MIL-S-901C	$1300 (1)	3-PHASE/WYE OPTION
100 mV p-p	0.2%	0.2%	MOS	100	UL, CSA, IEC, VDE	$172 (1)	
25 mV rms	±0.5%	±0.5% TO ±1.0%	MOS	100	DESIGNED TO UL, CSA, FCC-A	$195 (1)	INRUSH PROTECTION, LINE FILTER
25 mV rms	±0.5%	±0.5% TO ±1.0%	MOS	100	DESIGNED TO UL, CSA, FCC-A	$335 (1)	OPTIONAL AC-OK SIGNAL AND REMOTE SHUTDOWN
100 mV p-p	±0.1%	±0.2%	MOS	80	UL, CSA, IEC, VDE	$180 (1)	3-YEAR WARRANTY
100 mV p-p	±0.1%	±0.2%	MOS	80	UL, CSA, IEC, VDE	$360 (1)	OPTIONAL POWER-FAILURE MONITOR
100 mV p-p	±0.1%	±0.2%	MOS	80	UL, CSA, IEC, VDE	$545 (1)	OPTIONAL THERMAL SHUTDOWN
70 mV p-p	±0.2%	±0.3%	MOS	100	DESIGNED TO UL, CSA, FCC-A	$89.50 (1)	
50 mV p-p	±0.1%	±2.3%	MOS	100	DESIGNED TO UL, CSA, FCC	$114 (1)	RACK-MOUNT ENCLOSURE
50 mV p-p	±0.25%	±0.2%	MOS	100	DESIGNED TO UL, CSA, FCC	$134 (1)	
1% p-p	±0.2%	±0.4%	MOS	160	UL, CSA, IEC, VDE	$1000 (1)	5-YEAR WARRANTY; MULTIPLE-OUTPUT MODELS AVAILABLE
50 mV p-p	±1%	±1%	MOS	100	UL, CSA, VDE	$179 (1)	OPTIONAL STEEL COVER CAN PARALLEL 3 UNITS. 5-YEAR WARRANTY
20 mV p-p	±0.8%	±0.4%	MOS	150	UL, CSA	$599 (1)	
25 mV p-p	±0.6%	±0.3%	MOS	150	UL, CSA	$599 (1)	
100 mV p-p	±1.5%	±0.3%	MOS	100	UL, CSA, FCC-B	$185 (1)	
35 mV p-p	±0.1%	±0.1%	MOS	100	DESIGNED TO MIL-STD-810C, UL, CSA, FCC-A	$275 (1)	5-YEAR WARRANTY
35 mV p-p	±0.1%	±0.1%	MOS	100	DESIGNED TO MIL-STD-810C, UL, CSA, FCC-A	$725 (1)	CONVECTION COOLING
1% p-p	±0.6%	<4%	MOS	100	UL, CSA	$315 (1)	OPTIONAL POSITIVE AND NEGATIVE LINEAR REGULATORS
1% p-p	±0.4%	±0.4%	MOS	100	UL, CSA, VDE, IEC	$310 (1)	
1% p-p	±0.2%	±0.5%	MOS	100	UL, CSA, VDE	$110 (1)	
50 mV p-p	±0.01%	±0.05%	MOS	75	DESIGNED TO UL, CSA, VDE, BT	$193 (1)	MODULAR CONSTRUCTION
50 mV p-p	±0.01%	±0.05%	MOS	75	DESIGNED TO UL, CSA, VDE, BT	$405 (1)	
0.7% p-p	±0.2%	±0.2%	MOS	100	UL, CSA	$240 (1)	CONVECTION COOLING
50 mV p-p	±0.2%	±0.2%	MOS	200	UL, CSA, VDE, FCC-B, VDE (EMI)	$225 (1)	
50 mV p-p	±0.2%	±0.2%	MOS	200	UL, CSA, VDE FCC-B, VDE-B	$300 (500)	
1% p-p	±0.2%	±3%	BI	80	UL, CSA, VDE, FCC, VDE (EMI)	$749 (1)	
1% p-p	±0.2%	±3%	BI	60	UL, CSA, VDE, FCC, VDE (EMI)	$974 (1)	
0.2% +5 mV rms	±0.4%	±0.4%	MOS	100	MIL-STD-461, VDE	$3795 (1)	MILITARY APPLICATIONS
100 mV p-p	±1%	±2.5%	MOS	300	UL, CSA, FCC	$51 (1)	INCLUDES LINE CORD AND CAN BE PC-BOARD MOUNTED
100 mV p-p	±1%	±3%	MOS	300	UL, CSA, FCC	$120 (1)	
100 mV p-p	±0.5%	±2%	MOS	750	UL, CSA, VDE, ECI FCC, VDE (EMI)	$210 (1)	
1% p-p	±1%	±1%	BI	60	UL, CSA, IEC, VDE FCC, VDE (EMI)	$535 (5)	
1% p-p	±1%	±1%	BI	60	UL, CSA, IEC, VDE FCC, VDE (EMI)	$535 (5)	TIGHTER REGULATION ON AUX OUTPUTS. THIRD OUTPUT IS DRIVEN BY MAGNETIC AMP
1% p-p	±2%	±2%	MOS	100	UL, FCC-A	$566 (1)	

SOLA SWITCHERS. THE POWERS THAT BE.



Sola, long recognized as the industry leader in power conditioning and uninterruptible power systems, announces the availability of switching power supplies through industrial distribution.

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CIRCLE NO 141

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acdc's new JF Series offers more than rugged reliability. Advanced technology such as Current Mode Control allows superior Transient Response:

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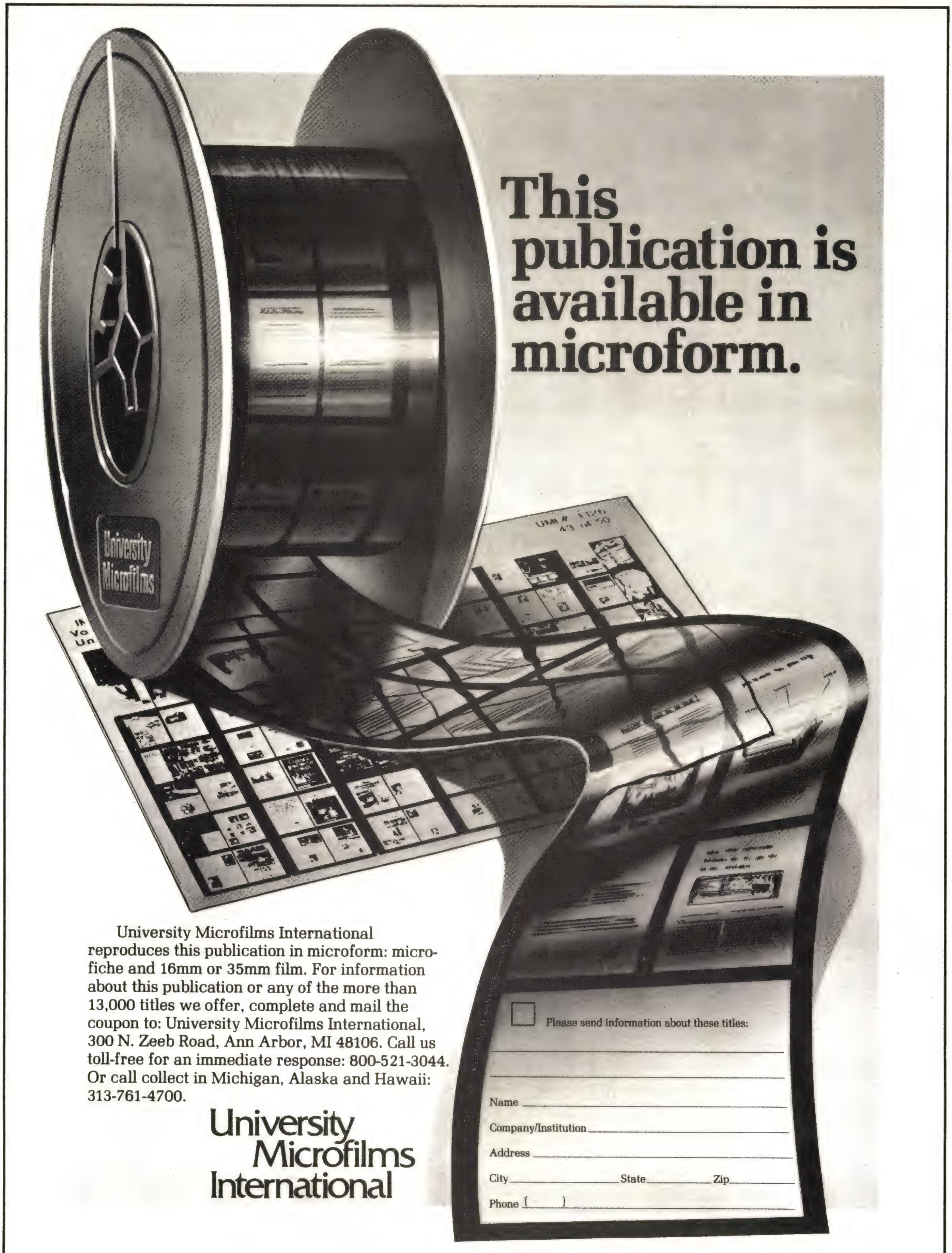

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Feed analog signals to IBM PC-compatible personal computers

A personal-computer-based data-acquisition system converts analog signals from low-level sensors—first, to a level an analog-I/O system can use, and second, to the digital ones and zeros the computer can use. Some guidelines can help you implement hardware and software solutions to the sometimes thorny interface problem.

John Croteau, Doug Grant, and Scott Wurcer,
Analog Devices Inc

By building a custom analog-I/O card for your IBM PC or compatible system, you can save money (as compared with commercially available cards) and realize a system that meets the particular requirements of your analog-input application. When building analog-I/O cards for personal computers, however, you must be aware of environmental influences and design tradeoffs. This article reviews those design considerations, offers some simple software-driver routines, and gives examples that demonstrate how various blocks in an analog-I/O system interconnect. The emphasis is on systems needing 12-bit accuracy.

The availability of low-cost, programmable hardware (the personal computer) allows you to build systems that collect, store, communicate, summarize, plot, and analyze data—and you can do all these tasks without incurring major capital expenditures (see **box,** "Should you buy or build?"). Such data might come from an electronic system that measures physical parameters—for example, pressure, temperature, flow, force, and light intensity. Inexpensive software tools are available for many of the mentioned tasks, and specialized tools are easy to develop with the aid of the high-level languages now available.

A transducer's analog electrical output requires some signal conditioning in order to produce an output that's useful to a system. In no case does a transducer deliver either a digital output or a clean, buffered, filtered, precisely scaled, 0 to 10V output that an A/D converter can use. The real world contains many deviations from the laboratory's ideal environment: Temperature fluctuates, noise intrudes, and signal transmission is rarely perfect. Furthermore, transducers used to measure physical phenomena don't offer zero output impedance or convenient output levels. Consequently, there is a need to convert these signals from the original analog format to a *useful* analog format, then finally to a digital format that a personal computer can interpret.

Depending on your specific application, you have several alternatives in system-design philosophy—alternatives that entail tradeoffs in speed, accuracy, and

A custom analog-I/O card for personal computers can save money and at the same time serve a particular application better than would a commercially available board.

cost. For instance, to monitor several slowly varying temperatures by using similar transducers, you might build a system that uses identical fixed-gain stages and a single accurate A/D converter preceded by a multiplexer. On the other hand, a system that needs high versatility (for example, one that monitors several types of signal sources) might require a software-programmable-gain amplifier (SPGA) in order to accommodate a wide range of input levels.

In either case, bear in mind that an analog system is only as good as the components it comprises. The multiplexer, SPGA, sample/hold amplifier, and A/D converter all contribute offset, gain, and linearity errors that degrade system accuracy. Although you can trim your circuits to reduce offset and gain errors, integral and differential nonlinearities and noise ulti-

Should you buy or build?

The possibilities for effecting an interface between analog signals and a personal computer can entail an expense of anywhere from a few tens of dollars to a few tens of thousands, depending on the hardware you choose. At one end of the spectrum are complete analog-I/O systems that connect to the PC through a standard RS-232C interface.

Such systems can perform not only the signal conditioning and analog-to-digital conversion, but also store the data, scale it, and communicate it to the host PC in a form fully converted to engineering units. Many such systems use fairly high-level commands to communicate with the host; these systems have probably the simplest interface requirements.

The disadvantage attached to such systems (besides their high prices) is that they sometimes contain so much intelligence that you must learn a new operating system or command set, which can be quite different from the PC's software. For laboratory-experiment applications, it's unfair to ask a lab technician to become a computer scientist merely to automate a data-gathering task.

One step down the cost ladder are board-level I/O subsystems, which can be attractive alternatives to large systems. Many I/O boards include a powerful subset of the features of the larger systems—for example, effective analog-signal-conditioning and data-conversion functions as well as some intelligence.

Some of these board-level subsystems offer interchangeable modules to adapt the board to various transducer types. These general-purpose board solutions typically represent an investment of a few thousand dollars, and are flexible enough to work with any host PC or minicomputer (because communication usually takes place through an RS-232 or similar port).

Machine-specific I/O

Another solution to the analog-world/digital-computer interface challenge is to use a machine-specific I/O card. Such boards are available from many vendors (often including the computer manufacturer itself), and include various combinations of analog and digital I/O. These boards represent a good investment, for several reasons.

First, the cost of a machine-specific board is generally much lower than that of a general-purpose, one-size-fits-all board. Second, the tight coupling of the I/O board to the bus allows fast communication of the digital data to the PC's memory, without the intervention of a slow communications link. Finally, you can control the board's operation in the native operating system or the PC's language; you therefore don't have to learn a new language or operating system.

Because the dedicated I/O board is most often the best choice, you must make the decision whether to buy or build the board. The advantage of buying a board is that no design or construction efforts are necessary. On the other hand, a custom-built board can include exactly the features needed in the application, and you can easily modify the board without concern for voiding a warranty. Such modifications might include upgrades for higher-performance components or additional channels, or an interface to a different transducer type.

mately limit system performance. In addition to using proper layout, bypassing, and grounding practices, you must scrutinize seemingly unimportant specs when you choose signal-conditioning components.

In systems using high values of gain, even small, second-order errors in the signal-conditioning chain become important when the errors enter the system prior to a gain stage. Such error sources are sometimes hard to find. It's useful to analyze each stage in an analog-input system to determine the stage's error contribution. You can then take steps during the design process to minimize the errors in each stage.

The front end, or analog-signal-conditioning part, of a data-acquisition system (DAS) might resemble the configuration shown in **Fig 1.** The system can accept signals from several different transducer types; each channel has its own amplifier. This remote-amplifier approach is often more desirable than one in which you send low-level signals around a noisy industrial environment or a noisy computer cabinet. The amplifier-per-channel approach has historically been prohibitively expensive, however, particularly in systems having many channels.

Newer-generation instrumentation amplifiers—for example, the AD524/624/625 family—make it possible to realize a cost-effective implementation of a high-accuracy, amplifier-per-channel data-acquisition front end. The availability of plastic-packaged versions of the amplifiers further enhances cost effectiveness. The AD524 and AD624 both have pin-programmable gain;

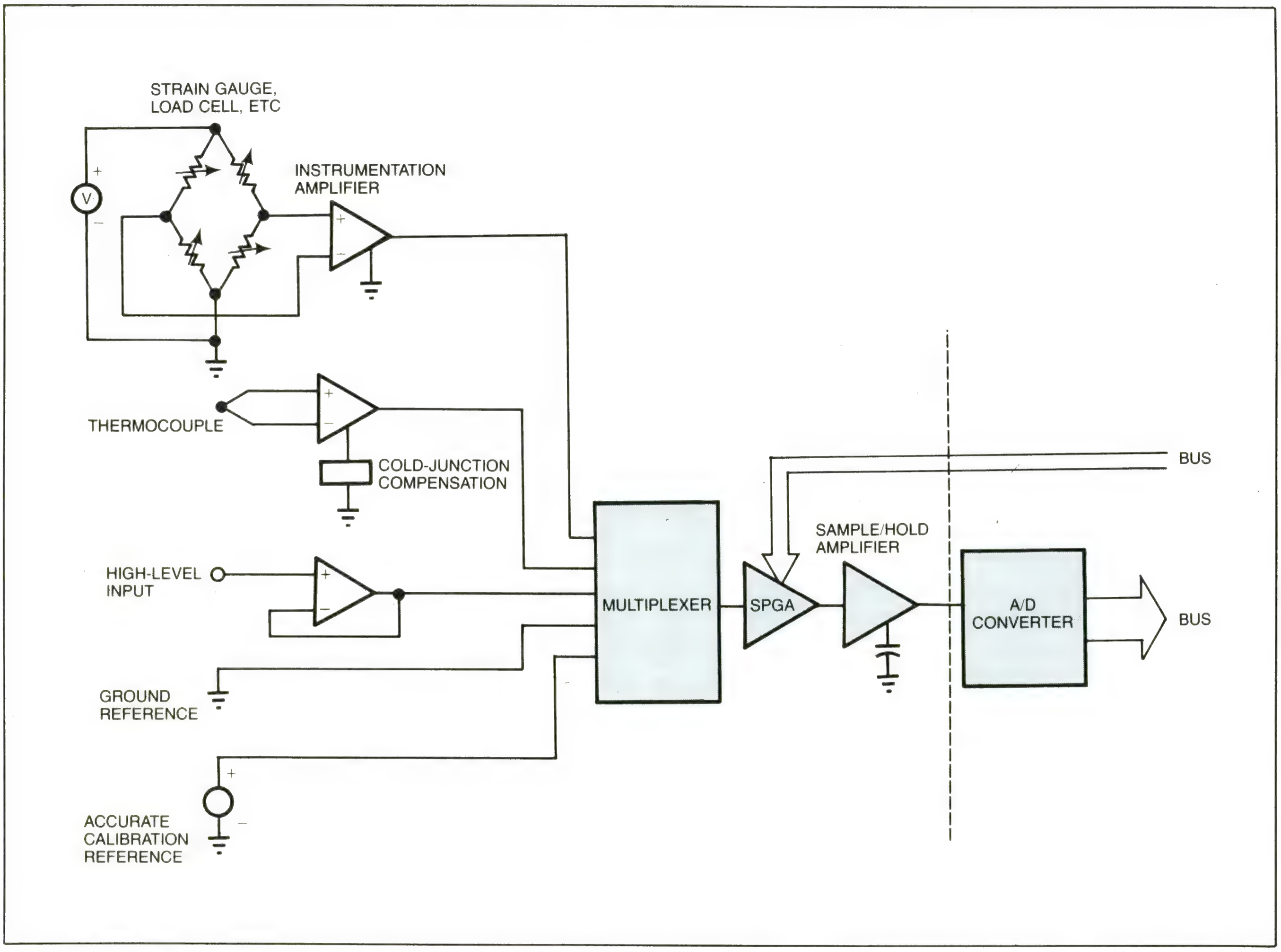


Fig 1—In this typical data-acquisition system, *a multiplexer routes the various analog-input signals to a software-programmable-gain amplifier. The sample/hold amplifier retains the value of a sampled signal while the A/D converter performs the conversion. The software signals to the SPGA adjust the amplifier's gain in accordance with the signal levels of the different input channels.*

you can use them without external components in fixed-gain applications. Instrumentation amplifiers offer several attractive advantages, such as true differential inputs and ground isolation (within the limits of the supplies).

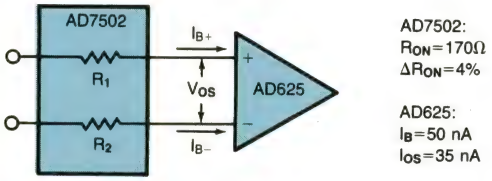
To understand the benefits offered by an instrumentation amplifier in data acquisition, consider **Fig 1**'s interface to the strain-gauge load cell. Strain gauges use a resistive-bridge configuration and are extremely linear and accurate, at the expense of yielding a very low full-scale output voltage (usually 10 to 40 mV). The AD624 is a good choice in this application; it offers pin-programmable gains of 1, 100, 200, 500, and 1000, thereby allowing the amplifier to raise the transducer's signals to several volts full scale.

Mounting the instrumentation amp right next to the transducer results in high rejection of potential noise sources and a low output impedance. If you need gains other than the mentioned fixed values, the AD625 is a better choice. This amplifier offers a 1 to 10,000 gain range that's determined by three external resistors. The amp can therefore accommodate virtually all standard industrial transducers. Resistance temperature devices and thermocouples are examples of other transducers that can benefit from precise signal conditioning at the transducer site.

The family of instrumentation amps employed here allows the use of an external power buffer inside the gain loop, thereby simplifying the task of driving very long cables between the transducer and the system. Such a buffer can prevent loss of bandwidth and preserve the signal's integrity. Without a buffer, most monolithic amplifiers oscillate when driving the large capacitive load of a long shielded cable. Furthermore, without the amp's sense connection, the inaccuracy of an outside-the-loop buffer can degrade signal accuracy. Instrumentation amplifiers having on-chip power-output stages tend to suffer from errors induced by the additional power dissipation.

Choosing a multiplexer

An input multiplexer can greatly enhance the cost effectiveness of a data-acquisition system by allowing a single A/D converter to serve many input channels. The most precise multiplexers usually use relay switching elements, and the best commercial signal multiplexers use reed relays. High-quality reed relays have a very large (about 10^{15}) ratio of off- to on-resistance, as well as very low leakage current (about 10^{-14}A) and offset voltage (about 2 μV). However, cost, size, speed, and power consumption are all problems inherent in the use of relays to multiplex analog signals.



$(R_1=R_2+\Delta R \text{ and } I_{B+}=I_{B-}+I_{OS})$

$V^+=I_{B+}R_1=(I_{B-}+I_{OS})(R_2+\Delta R)$

$V^+=I_{B-}R_2+I_{OS}R_2+I_{B-}\Delta R+I_{OS}\Delta R$

$V^-=I_{B-}R_2$

$V_{OS}=V^+-V^-=I_{OS}R_2+I_{B-}\Delta R+I_{OS}\Delta R$

$V_{OS}=6.3\ \mu V$

Fig 2—Multiplexer-induced errors come from two sources: *multiplexer on-resistance, and the instrumentation amplifier's input-bias currents. More accurately, the major sources of error are the disparity between the on-resistances of the multiplexer's different channels and the difference between the amplifier's two bias currents.*

If you can design around their shortcomings, JFET or CMOS multiplexers are preferable. JFET (including BiFET) multiplexers have on-resistances that are higher than those of relays, and the on-resistances are nonlinear with current and voltage. JFET multiplexers also have higher leakage currents than relays, and these currents are very temperature sensitive. MOSFETs have even higher on-resistances, as well as back-gate-to-substrate leakage. This leakage results in high off-current errors.

Another key difference between JFET and MOSFET multiplexers is their behavior in supply-sequencing situations. JFET multiplexers have the annoying (and potentially problematic) characteristic of turning all channels on upon loss of power. Multiple, separately powered signal sources sharing a JFET multiplexer could thus find themselves all shorted together upon the loss of power to the multiplexer. Furthermore, JFET and junction-isolated CMOS devices are prone to latch-up if signal levels exceed the supply voltages. Dielectrically isolated CMOS multiplexers are immune to this latch-up effect.

Reduce multiplexer errors

To obtain maximum signal-transmission integrity, your system should provide the multiplexer with a low-impedance source and a high-impedance load.

You must tailor the signal-conditioning function at the front end of your data-acquisition system to suit the requirements of the transducers.

These conditions prevent leakage errors from exerting a large effect and ensure that leakage currents through the multiplexer are small (resulting in low offset). You shouldn't multiplex very-low-level signals with JFET or MOSFET multiplexers, because any errors in the multiplexer will be large with respect to those signals.

Fig 2, for example, shows a configuration in which a differential analog input is multiplexed into a programmable-gain amplifier (PGA). The PGA's offset current (the difference in the bias currents of the two inputs) produces a small offset voltage as the current flows through the multiplexer's on-resistances. A second offset error arises from the difference in on-resistances between the multiplexer's channels and the PGA's bias currents. In a system with a gain of 1000, the 6.3-μV input offset, calculated in **Fig 2** for an AD7502 and AD625, would yield a trimmable output offset voltage of 6.3 mV.

You must trim the described offsets—and all others prior to the gain stage—at a point in the circuit *before* the gain stage if you wish to select multiple gain settings using software control. Otherwise, the offsets take on different values with each gain setting and as a consequence prevent your trimming them at a later point.

To make optimum use of the dynamic range of an A/D converter, it's necessary to adjust the front-end gain for each input. You must adjust the gain so that the full-scale voltage for each input is as close as possible to the full-scale input of the converter. A system that must handle inputs over a very wide dynamic range could use an SPGA to accomplish the gain adjustments. The AD625 SPGA building block, combined with a resistor network and a CMOS switch, forms a versatile SPGA **(Fig 3).** This SPGA could provide just a few bits of dynamic range, or an entire 512-to-1 gain prescaling.

The AD625 exhibits no signal-related change in current in the sense inputs, so the gain network simply becomes a switchable feedback attenuator in which the switch resistance causes only second-order errors. CMOS switches are adequate in this application for 12-bit performance. Gain accuracy and temperature coefficients are primarily functions of the quality of the external resistors. The gain network should therefore comprise resistors that furnish a low temperature coefficient and ≤1% tolerance, or a packaged resistor network.

Noise and other gremlins

In general terms, noise is anything that interferes with a measurement, whether the interference be random or periodic. It's beyond the scope of this article to do complete justice to the subject of noise, but some major topics are worthy of brief mention.

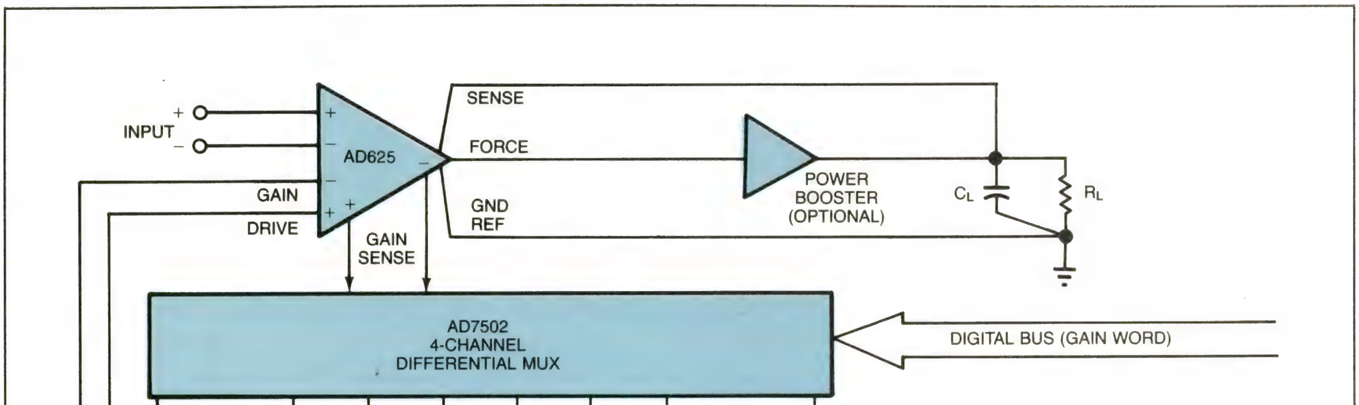


***Fig 3—You can build your own software-programmable-gain amplifier** using readily available IC building blocks. Here, the 4-channel multiplexer selects the gain-setting resistors for the instrumentation amplifier. Note that the optional power booster is inside the gain loop, thereby eliminating errors that could arise from the booster's nonlinearities.*

In designing a front end for an analog-I/O system, you should be aware of the various error sources and how they affect total system accuracy and linearity.

Thermal, or Johnson, noise is a fundamental limiting factor in the accuracy of many measurements. Take, for instance, the quasistatic case of a mass on a load cell. Even a perfect 350Ω load cell has 2.4 nV/$\sqrt{Hz}$ of noise that, in a 10-Hz bandwidth, contributes approximately 2.3 ppm p-p of a 20-mV full-scale output.

Bandwidth reduction is one way to reduce the effects of noise. You'd typically use a multipole filter with a low cutoff frequency (say, 3 Hz) to prevent as much as possible of the non-dc information from arriving at the A/D converter. The actual circuit noise eventually assumes a 1/f nature, and additional filtering offers diminishing returns. The AD624 specs 0.2-μV p-p noise in a 0.1- to 10-Hz bandwidth. This spec results in a 10-ppm resolution limit for a 20-mV full-scale input.

Proper attention to grounding, shielding, and supply bypassing can result in considerably improved performance before you do any filtering, which only reduces undesired effects after the fact. **Fig 4a** shows some of the interference-type noise existing in a differential-amplifier circuit. Shielded twisted-pair cables offer good noise rejection; the twist prevents the formation of a magnetic loop, and the balanced nature of the line holds electrostatic pickup to the status of a common-mode error. In the schematic in **Fig 4a,** the op amp senses ground remotely. This connection maintains a

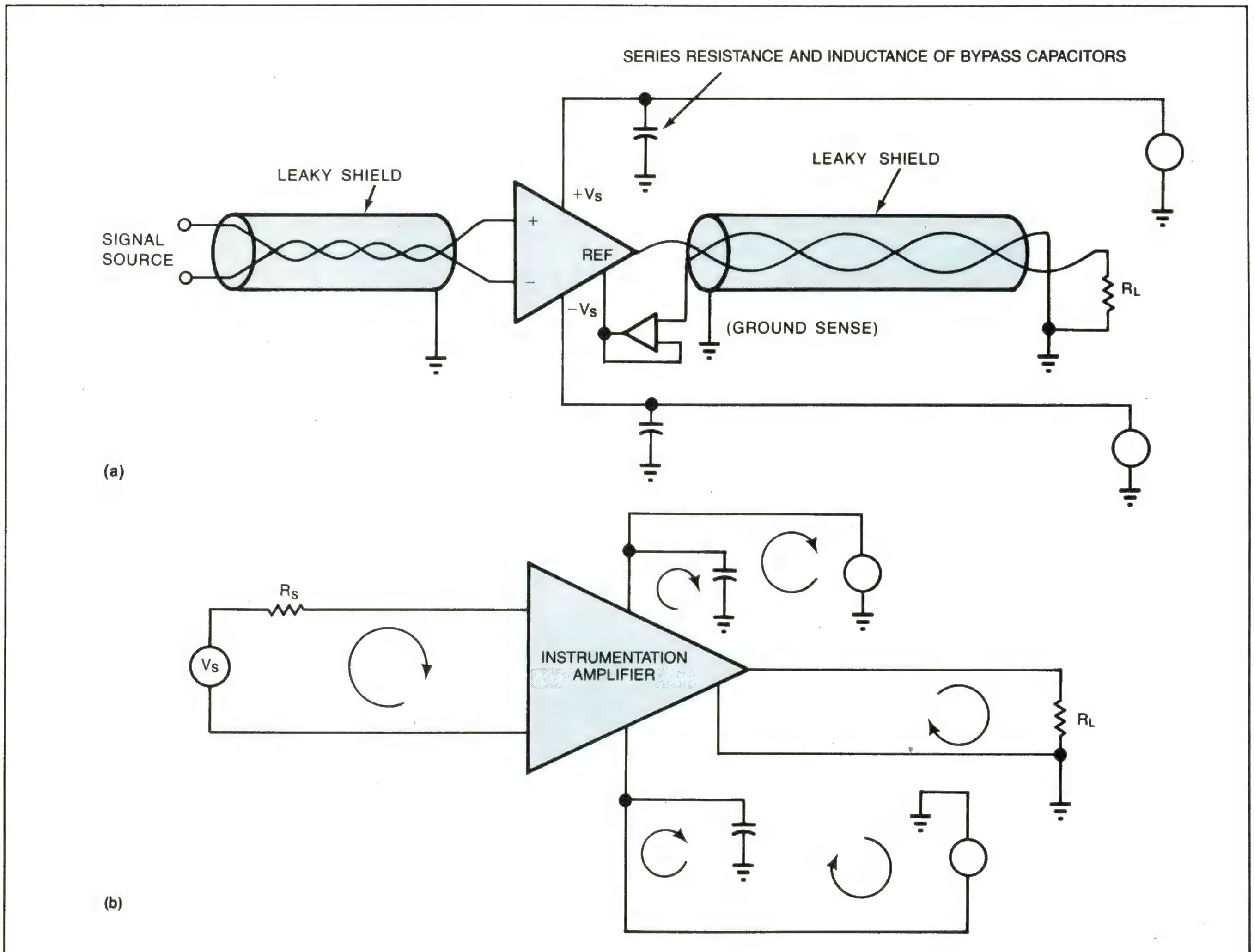


Fig 4—A high-gain amplifier circuit contains several sources of error. *In **a**, leaky shields and imperfect bypass capacitors produce interference-type noise. The op amp senses ground remotely, resulting in a large difference between input and output grounds. Transformer coupling is the gremlin in **b**; electromagnetic fields can couple line harmonics and load currents back into the amplifier's inputs.*

considerable difference between the input and output grounds, a difference that causes no error.

Current delivered to a load from the supply lines can cause coupling of a signal back into the circuit through transformer action. Similarly, transformer action can couple any of the loops shown in **Fig 4b** back into the input loop. Furthermore, power-supply transformers can couple line harmonics as well as signal current back into these sensitive inputs. Most amplifiers exhibit decreasing supply rejection with increasing frequency, making them particularly susceptible to high-frequency electromagnetic coupling. It's good practice to decouple all supplies using capacitors that provide efficient bypassing to frequencies well beyond the signal-frequency range.

Noise and coupling phenomena are not the only problems that beset data-acquisition systems. Thermal-EMF effects can seriously degrade the dc performance of a data-acquisition system, especially at high gains. Any junction of dissimilar metals generates a potential that varies with temperature. The junction of a gold-plated Kovar IC lead with a copper pc-board run can have as much as 50 μV/°C of thermocouple voltage. You should, therefore, take care to balance all thermocouples in a dc circuit.

Be sure to keep all sensitive circuitry at equal

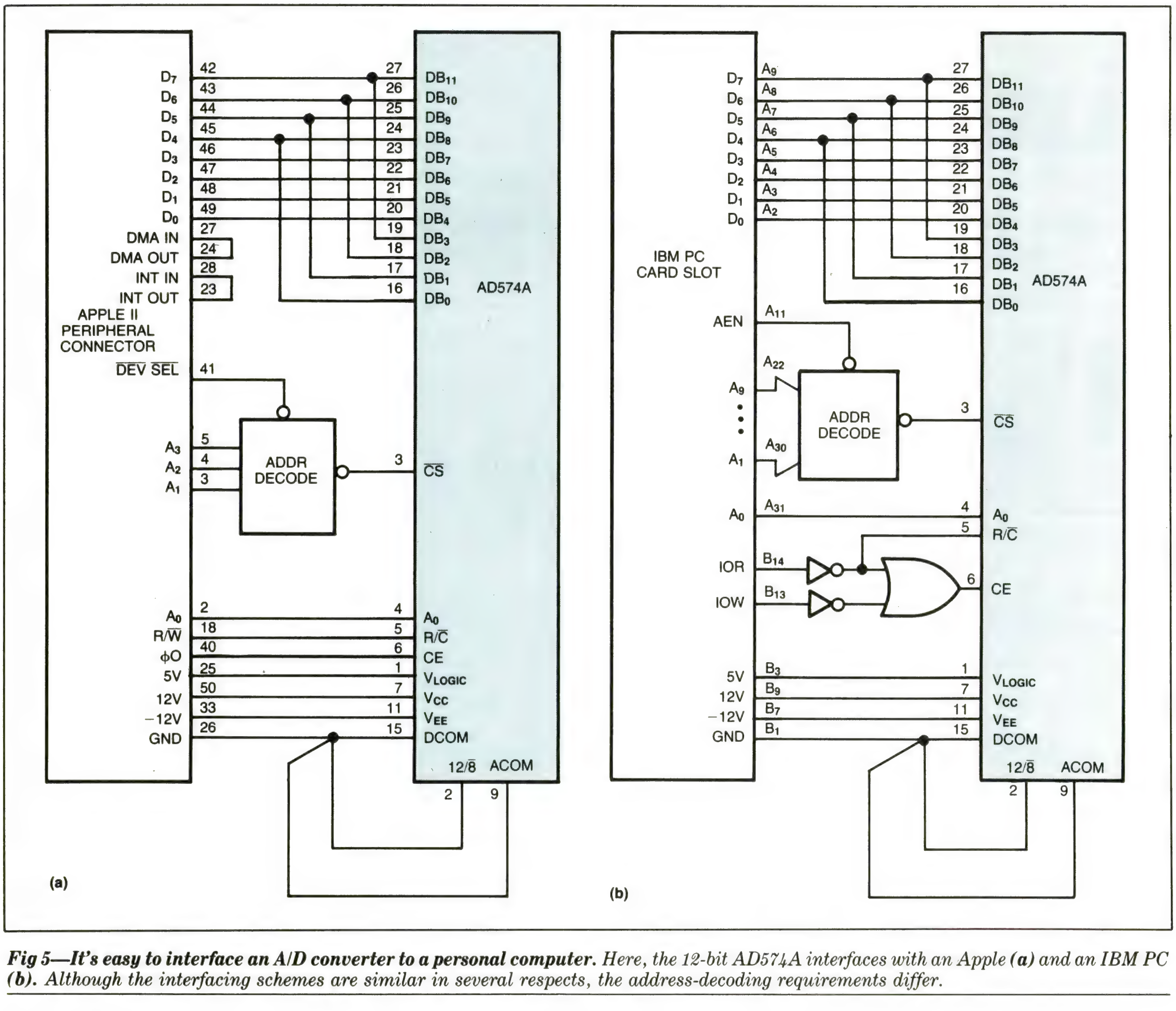


Fig 5—It's easy to interface an A/D converter to a personal computer. Here, the 12-bit AD574A interfaces with an Apple (a) and an IBM PC (b). Although the interfacing schemes are similar in several respects, the address-decoding requirements differ.

An input multiplexer can greatly enhance the cost effectiveness of a data-acquisition system by allowing a single A/D converter to serve many input channels.

temperatures. You must also consider the positioning of heat-generating components and the heat-sinking effects of large pc-board runs. Air currents from fans or from convection will differentially excite even the most carefully balanced junctions, thereby causing spurious low-frequency noise. Because of the mentioned error sources, it's good practice to physically (and therefore thermally) isolate a system's front end.

High-impedance circuitry suffers from its own set of error sources. In this case, charge coupled into high resistances is the major culprit. Vibrating wires and capacitors exhibit microphonic behavior, which is particularly difficult to track down and eliminate. Because the vibration varies the spacing of conductors, thereby varying their capacitance, the voltage observed between the conductors varies. Because much of the vibration in electronic systems comes from cooling fans whose rotation speeds are synchronized with the ac line, you could mistake such microphonic-type errors for electromagnetic pickup. Avoid loose connectors and unsecured signal-carrying leads; tying or gluing down the offending components can make a big difference in performance.

Assuming you've implemented all the preceding error-reduction suggestions, and a properly buffered, filtered, and scaled analog signal is now present in the system, you still must get the signal into the system's A/D converter. The task is more difficult than you might expect. Sample/hold (S/H) amplifiers are often used to avoid dynamic errors in conversion systems. In a multichannel system, an S/H amplifier allows the analog front end to begin settling to the next channel during the time one channel is undergoing conversion. Even in single-channel systems, an S/H amplifier can increase a converter's signal bandwidth, by reducing the converter's effective aperture time.

Because the S/H amplifier acts as an analog storage unit during a conversion cycle, its dynamic output impedance must be low enough to maintain an accurate output in the presence of the dynamic load presented by a successive-approximation A/D converter. An S/H amplifier exhibits a sample-to-hold offset, or pedestal, arising from charge transfer from the switch to the hold capacitor. In some S/H units, the amount of charge varies with the applied signal voltage, resulting in a nonlinearity that can seriously degrade system accura-

```
5 DEF SEG = &H1700
10 SCREEN 1: COLOR 9,1: KEY OFF: CLS
20 REM    INPUT TRIGGERING AND SCALING INFORMATION
30 PRINT"          DIGITAL OSCILLOSCOPE":PRINT
35 PRINT"INPUT RANGE IS +/-5V, WITH 2.44mV       RESOLUTION"
36 PRINT   :INPUT"SINGLE- OR CONTINUOUS-SWEEP (s,c)";E$
37 PRINT   :INPUT"NORMAL OR AUTOMATIC TRIGGER (n,a)";D$
39 IF D$="a" THEN GOTO 52
40 IF D$="A" THEN GOTO 52
45  PRINT   :INPUT"TRIGGER ON POS OR NEG SLOPE (p,n)";A$
46 PN% = 1
48  IF A$="n" THEN PN% = 0
49  IF A$="N" THEN PN% = 0
50 GOTO 55
52 PN%=2
55 PRINT   :INPUT "INPUT SCREEN'S CENTER VALUE (+/-V)";CTR
70 PRINT   :INPUT"OFFSET TRIGGER PT FROM CTR SCREEN (y,n)";A$
80 IF A$="y" THEN GOTO 100
85 IF A$="Y" THEN GOTO 100
90 OFFSET = 0: GOTO 110
100 PRINT   : INPUT "OFFSET BY HOW MUCH (+/-mV)";OFFSET
110 IF (CTR+OFFSET/999.99) > 4.998 THEN GOTO 135
120 TRVAL% = INT(409.6*CTR + OFFSET/2.4414 +.5) * 16
130 GOTO 140
135 TRVAL% = 32752
140 PRINT   : INPUT"HOW MANY mV/div";DIV:PRINT
150 RNG = INT (3.2768*DIV +.5)
170 INPUT"HOW MANY ms/div (2.1ms MINIMUM)";MS:PRINT
175 IF MS < 2.1 THEN MS = 2.1
180 DLY% = INT(MS/.15016 - 7.4914)
190 BX% = TRVAL% - 1
200 IF PN% = 1 THEN BX% = TRVAL% + 1
201 REM      SPECIFY SCALES AND DRAW GRATICULES
203 CLS: LOCATE 2,4:PRINT DIV;"mV"
205 LOCATE 2,30: PRINT MS;"ms"
210 FOR J = 25 TO 175 STEP 25
220 FOR I = 1 TO 320
230 PSET (I,J),1
240 NEXT I: NEXT J
270 FOR I = 40 TO 280 STEP 40
280 FOR J = 1 TO 200
290 PSET (I,J),1
300 NEXT J: NEXT I
305 Q = 200/RNG
306 F%= INT(409.6*CTR - RNG/2 +2048.5)
310 I%= 400: J%= 1050
315 REM      EXCHANGE MEMORY RANGES AND CALL SUBROUTINE
320 L%= I%: I%= J%: J%= L%
340 P=0
350 CALL P(BX%,I%,TRVAL%,PN%,DLY%)
355 REM      SCAN SCREEN ERASING OLD AND DRAWING NEW WAVEFORM
360 FOR X = 0 TO 560 STEP 80
370 FOR Y = 2 TO 78 STEP 2
380 W =200-INT(Q * (PEEK(J%+X+Y)/16+PEEK(J%+X+Y+1)*16-F%)+.5)
390 IF INT(W/25)=W/25 THEN GOTO 410
400 PRESET ((X+Y)/2,W)
410 W=200-INT(Q * (PEEK(I%+X+Y)/16+PEEK(I%+X+Y+1)*16-F%)+.5)
420 IF INT(W/25) = W/25 THEN GOTO 440
430 PSET ((X+Y)/2,W),2
440 NEXT Y:NEXT X
442 REM CONTINUE IF CONTINUOUS SCAN, OTHERWISE PROMPT FOR RE-SCAN
444 IF E$="S" THEN GOTO 460
446 IF E$="s" THEN GOTO 460
450 GOTO 320
460 LOCATE 22,1
465 INPUT"AGAIN (y,n)";T$
470 IF T$="N" THEN END
480 IF T$="n" THEN END
490 LOCATE 22,1:PRINT"______________"
500 GOTO 320
```

Fig 6—High-level languages are useful in data acquisition. *This Basic routine turns an IBM PC into a digital oscilloscope. The program allows you to enter trigger data and time and voltage scales. It also draws the screen's graticules and displays the scales. The program works with the PC's assembly language, via CALL statements. The oscilloscope system needs only a sample/hold amplifier and an A/D converter as hardware.*

cy, especially if the S/H amplifier resides at a point prior to a gain stage.

The pedestal effect is prevalent in high-throughput systems that require small hold capacitors for quick signal acquisition and settling. High throughput also requires short sampling periods and long hold times, a combination that can produce a memory effect because of dielectric absorption in the hold capacitor. An untrimmable error results from charge left on the capacitor from the previous hold period. Teflon, polystyrene, and MOS capacitors offer the best performance; their dielectric-absorption coefficients are on the order of 0.02% or less.

The A/D converter at last

With the buffering, filtering, scaling, sampling, and holding accomplished, the remaining task is to select an A/D converter that has the speed, resolution, and accuracy suitable for your application. For the examples discussed here, the chosen converter is the AD574A. This 12-bit A/D converter offers a 25-μsec conversion time and 12-bit linearity, and it comes with a guarantee of no missing codes over its full operating-temperature range.

Essentially an analog-input port, the A/D converter resides in the PC's address space just as any other I/O port would. It can accept either memory-mapped or isolated-I/O modes of access, and it can lie in one or more locations, depending on the number of cycles needed to read its digital output. Signals generated from the decoded address (or addresses), the read/write line (lines), and assorted control signals supply the converter's control inputs. The control inputs signal the converter when to begin a conversion and when to put its output on the data bus.

Once the A/D converter completes the conversion cycle, it must communicate its digital output to the PC. Many converters offer onboard, 3-state output buffers, which allow the units to interface directly with the PC's data bus. The output format and logic depend on the converter's resolution relative to the width of the data bus. If the bus is wider than the data word, a single cycle can read the input "broadside" (ie, all bits at once), but if the word is wider than the data bus, multiple cycles must read the word in portions.

The data format becomes a concern if the output word's length is larger than, but not an exact multiple of, the width of the data bus. For instance, when the AD574A interfaces with an 8-bit system, as in **Figs 5a** and **5b**, the system must read the 12-bit output as one 8-bit byte and one 4-bit nibble. One read cycle obtains the eight MSBs, and a subsequent cycle obtains the four LSBs (with four trailing zeros for the unused bits). Data in such a form is said to be left justified. Alternatively, if the eight LSBs are in one byte and the four MSBs are in another, the data is right justified.

```
         PUSH  BP            ; SAVE BP
         MOV   DX, 0309      ; SET ADC ADDRESS
         MOV   BP, SP        ; SET BASE PARM LIST
         MOV   S1, [BP] +14  ; GET ADDR OF BX%
         MOV   BX, [S1]      ; GET VALUE OF BX%
         MOV   S1, [BP] +12  ; GET ADDR OF I%
         MOV   D1, [S1]      ; GET VALUE OF I%
         JMP   START         ; JUMP TO BEGIN
NOTRIG   MOV   BX, AX        ; SAVE AS LAST CONVERSION
START    OUT   DX, AL        ; START CONVERSION CYCLE
         MOV   CX, 7         ; SET UP DELAY
WAIT     LOOP  WAIT          ; LOOP TO WAIT FOR ADC
         MOV   S1, [BP] +10  ; GET ADDR OF TRVAL%
         MOV   CX, [S1]      ; GET  VALUE OF TRVAL%
         MOV   S1, [BP] +8   ; GET ADDR OF PN%
         DEC   DX
         IN    AX, DX        ; RETRIEVE CONV RESULT
         INC   DX
         XOR   AX, 8000      ; CHANGE TO 2's COMP
         CMP   [S1], 2       ; AUTO OR NORMAL TRIGGER?
         JE    TRIG          ; IF AUTO, TRIGGER
         CMP   [S1], 1       ; POS OR NEG TRIGGER?
         JNE   NEGTR         ; JUMP IF NEG, ELSE POS
         CMP   BX, CX        ; LAST CONV > TRVAL%?
         JG    NOTRIG        ; IF NOT, TRY AGAIN
         CMP   AX, CX        ; THIS CONV < TRVAL%?
         JL    NOTRIG        ; IF NOT, TRY AGAIN
         JMP   TRIG          ; ELSE, TRIGGER
NEGTR    CMP   BX, CX        ; LAST CONV < TRVAL%?
         JL    NOTRIG        ; IF NOT, TRY AGAIN
         CMP   AX, CX        ; THIS CONV > TRVAL%?
         JG    NOTRIG        ; IF NOT, TRY AGAIN
TRIG     MOV   BX, 0         ;  INITIALIZE MEMORY FLAG
NXTPT    XOR   AX, 8000      ; CHANGE TO BINARY
         OUT   DX, AL        ; START CONVERSION CYCLE
         MOV   S1, [BP] +6   ; GET ADDR OF DLY%
         MOV   CX, [S1]      ; GET VALUE OF DLY%
DLY      LOOP  DLY           ; LOOP TO DELAY FOR ADC
         MOV   [D1], AX      ; STORE LAST CONV RESULT
         INC   D1            ; INCREMENT TO NEXT
         INC   D1            ;  STORAGE ADDRESS
         INC   BX            ; INCREMENT MEMORY FLAG
         DEC   DX
         IN    AX, DX        ; RETRIEVE CONV  RESULT
         INC   DX
         CMP   BX, 0140      ; 320 POINTS YET?
         JNE   NXT PT        ; IF NOT, INPUT NEXT PT
         POP   BP            ; RESTORE BP
         RET   10            ; FAR RETURN TO BASIC
```

*Fig 7—**This IBM-PC-based assembly-language subroutine** works in conjunction with **Fig 6's** Basic program. The subroutine accepts five arguments, which control triggering and timing data.*

Rely on general-purpose converters

General-purpose converters usually offer flexible interfaces and various pin- and software-programmable options. For example, the AD574A has a software-

Proper attention to grounding, shielding, and supply bypassing can improve system performance considerably.

programmable output-word length (eight or 12 bits) and a pin-selectable output format **(Table 1).** If you apply a one and a zero to CE and $\overline{CS}$, respectively, and a zero to R/$\overline{C}$, a 12- or 8-bit conversion results, depending on the status of A_0. Holding R/$\overline{C}$ high, however, enables the 3-state outputs.

During the read cycle, 12/$\overline{8}$ defines which bits are enabled; if this line is high, all 12 bits are read broadside. If 12/$\overline{8}$ is low, only the eight MSBs or the four LSBs are enabled, depending on the status of A_0. Timing diagrams in the AD574A's data sheet define all control inputs and outline certain setup, hold, and bus-access times. You must take into account the PC's bus-timing and propagation delays when you specify control signals and decoding/logic schemes.

The interfaces in **Figs 5a** and **5b** satisfy all timing requirements for the AD574A and the two indicated personal computers. In **Fig 5a,** the Apple's Device Select control signal acts as an upper-address decode for the particular card slot and limits the number of I/O addresses per slot to 16. If none of the other 16 possible addresses are used in that slot, you can connect the Device Select pin directly to the AD574A's $\overline{CS}$ input.

You can treat the AD574A either in memory-mapped mode or as isolated I/O for the IBM PC. In **Fig 5b,** the computer uses its IOR and IOW lines to treat the converter as isolated I/O. Isolated-I/O address decoding and troubleshooting are easy with the IBM PC, because the computer uses only the lower 10 address lines (A_9 to A_0). However, you need AEN to mask out DMA cycles that use the same address space.

You can use any language to execute the read and write cycles that control the A/D converter. In Basic, you use PEEK and POKE commands if the device is

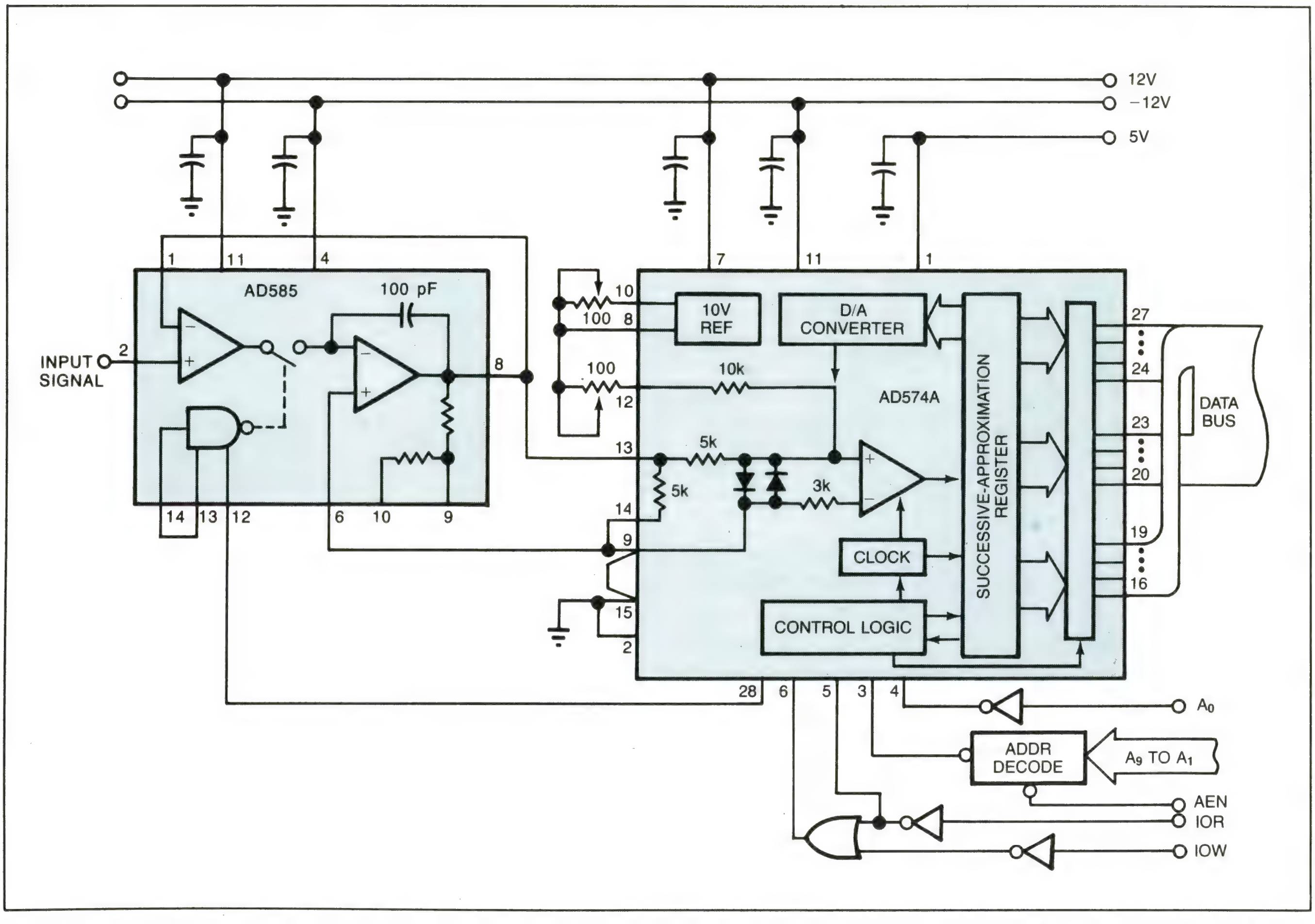


Fig 8—You increase the effective signal bandwidth of an A/D converter *by using a sample/hold amplifier to freeze signals during conversions. In this configuration, the AD585 S/H device drives an AD574A. Note that few external components are required; the two potentiometers shown adjust offset and gain errors in the A/D converter.*

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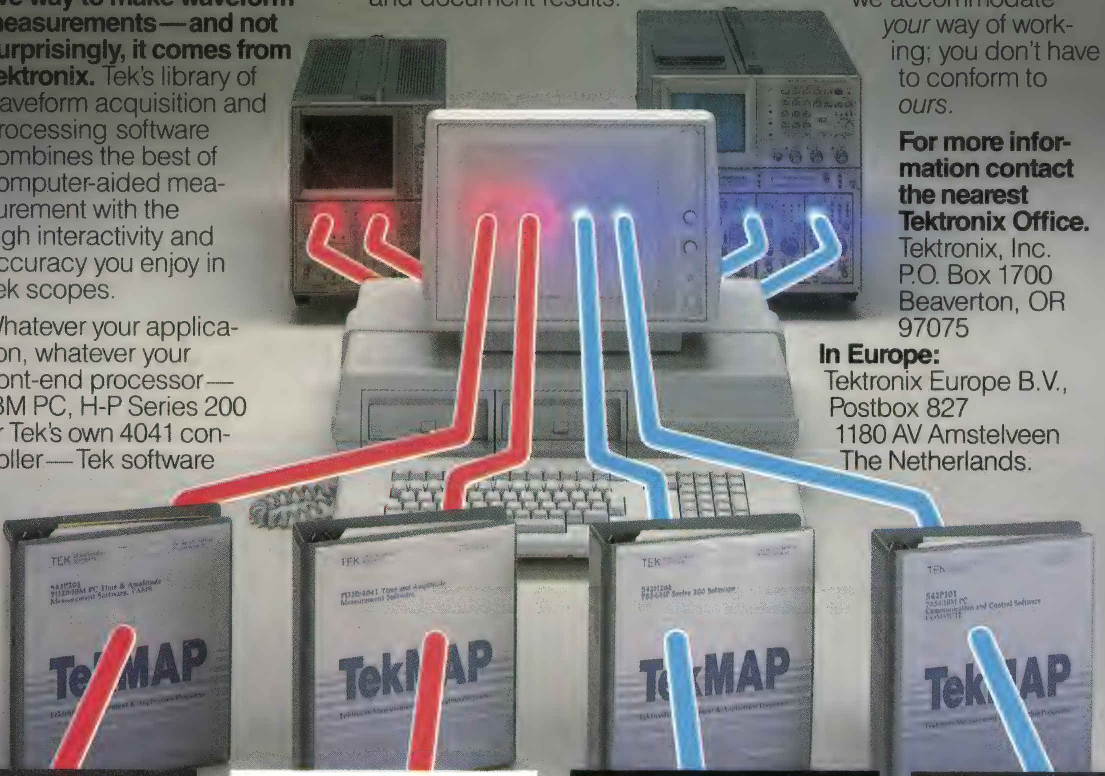
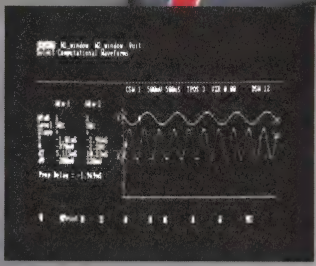
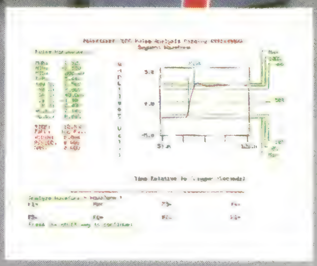
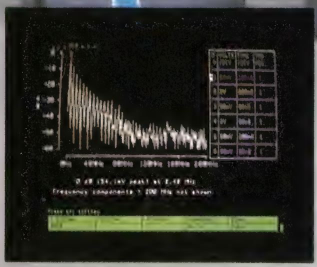




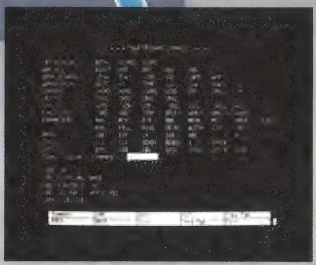
Delay time measurement using an IBM PC/XT/AT as controller with Tek's Time and Amplitude Measurement Software. Instruments: the Tek 7D20 Programmable Digitizer and Tek 7603 oscilloscope.



Automated pulse parameter analysis using a Tek 4041 Controller and Tek Time and Amplitude Measurement Software to direct the efforts of the 7D20 in a 7603 mainframe. Hard copy generated by a Tek 4695 Color Copier.



Computing and displaying frequency domain data (FFT), using an HP Series 200 Technical Computer as controller. Tek software for these results accommodates the HP Series 200 with the Tek 7D20 or the Tek 7854 Waveform Processing Oscilloscope.



Editing a Tek 7854 RPN program, including comments, for downloading to the 7854 or archiving to disk. Performed with the HP 200 Series Technical Computer, the Tek 7854, and Tek 7854/HP Series 200 Software. Similar facility available in COMMUTE.

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To communicate the results of A/D conversions to a personal computer, you can use both high-level- and assembly-language programs.

TABLE 1—AD574A TRUTH TABLE

CE	$\overline{CS}$	R/$\overline{C}$	12/$\overline{8}$	A_0	OPERATION
0	X	X	X	X	NONE
X	1	X	X	X	NONE
1	0	0	X	0	INITIATE 12-BIT CONVERSION
1	0	0	X	1	INITIATE 8-BIT CONVERSION
1	0	1	5V	X	ENABLE 12-BIT PARALLEL OUTPUT
1	0	1	GND	0	ENABLE 8 MOST SIGNIFICANT BITS
1	0	1	GND	1	ENABLE 4 LSBs + 4 TRAILING ZEROS

memory mapped, while INP and OUT statements apply if the converter is operating as isolated I/O. In addition, most PCs offer the capability to call machine-language subroutines from Basic. The fast execution times of assembly-language commands offer the designer higher throughput per channel and a faster number-crunching capability.

By integrating assembly-language routines into high-level programs, you can take advantage of both the speed of the assembly language and the programming ease of the high-level languages. For example, the program in **Fig 6,** written in Basic for the IBM PC, uses the PC's graphics capability to configure a digital oscilloscope, using the medium-resolution mode on a color monitor. The first portion of the program, written in Basic, prompts the user to enter the trigger data and the time and voltage scales. It then draws the graticules on the screen and displays the scales.

The program then calls the **Fig 7** assembly-language subroutine with five arguments that supply the triggering and timing data. The subroutine returns with 320 data points stored in one of two memory ranges. The other range contains the previous scan's points. The final portion of the program scans the screen while scaling both sets of data points, erasing the previous waveform and displaying the new waveform. In the single-scan mode, you can request additional scans after each sweep. In the continuous-scan mode, however, the program proceeds to trigger, acquire, erase, and display until you enter Control-Break.

Scope hardware requirements are minimal

The only hardware requirements for the digital oscilloscope are an AD574A and an AD585, connected as shown in **Fig 8.** The configuration accepts a ±5V input (perhaps from a transducer-input front end as described earlier). Because the IBM PC's 8088 µP reads a 2-byte word whose most significant byte is at the lower address, the IN command in the subroutine requires the inversion of address line A_0 in the interface shown in **Fig 5a.** In contrast, an INP statement in Basic is an 8-bit operation, so you can eliminate the need for the inverter by accessing the converter with the MSB at the higher address.

The CALL statement in **Fig 6**'s line 350 transfers control to the subroutine found in segment &H1700, as defined in the previous DEF SEG statement. The arguments BX%, TRVAL%, and PN%, passed to the **Fig 7** subroutine, communicate the triggering information, while I% indicates which of the two ranges of memory to use. The final argument, DLY%, controls a variable delay between conversions, thereby setting the time scale. The subroutine continuously samples the input until the triggering conditions are met, and it then proceeds to the bottom portion of the program, which enters 319 more points and stores all 320 in memory. Throughout the subroutine, the stack stores the branch pointer (BP), and the intersegment return at the end transfers control back to the Basic program.

Calibrating the system

All dynamic and static errors introduced by the system's individual components combine to define the system's accuracy. Most often, you can trim the offset and gain errors at each component. However, if the square root of the sum of the squares of the offset and gain errors is small enough, you can effect the entire system's calibration at the A/D converter. You can use either a hardware- or software-based trimming approach to eliminate errors.

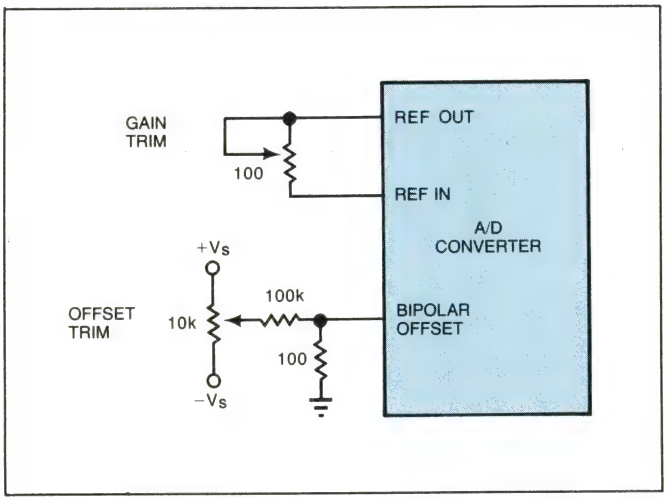


Fig 9—Trimming an A/D converter's offset and gain is easy, *but beware: Trimming potentiometers might not offer enough resolution to make up for errors arising in other parts of the system.*

General-purpose A/D converters usually offer flexible interfaces and various pin- and software-programmable options.

Most often, you trim offset by injecting or draining a small amount of current into or from the A/D converter's input at the high-impedance summing node. Because an A/D converter produces an output that's proportional to the analog input relative to a full-scale (reference) voltage, you can trim gain errors by either varying the reference voltage or adjusting the gain of a preceding stage. Calibration then requires the application of two known analog voltages. The first voltage, near zero, trims the offset. You apply this voltage to the converter's input and trim the offset-trim current until the converter's output matches the desired code. You then apply the second known voltage, near full scale, and adjust the gain until the output matches the correct, near-full-scale code.

Hardware vs software trims

Hardware-based trimming schemes **(Fig 9)** have traditionally used potentiometers for the offset and gain adjustments. However, a trimming potentiometer might not offer sufficient resolution to trim several components' offset and gain errors at a single point in the system, because in single-point trimming the trim range can become quite large. For instance, a ±20% offset-trim range in a 12-bit system would span 819 LSBs. A 10-turn potentiometer would trim 82 LSBs per turn, and thus offer 4.4°/LSB resolution. Such fine resolution requires precise calibration and risks both mechanical instability and the temptation on the part of untrained personnel to inadvertently recalibrate the system.

Instead of using hardware to calibrate the system, you can correct gain and offset errors entirely in software. To do so, you might need to offset (and possibly expand) the A/D converter's input range to accommodate a signal that has worst-case offset and gain errors. Begin the trimming algorithm by performing a conversion of a known analog voltage near zero scale. Because gain errors in the lower portion of the transfer function are negligible, the measured input's

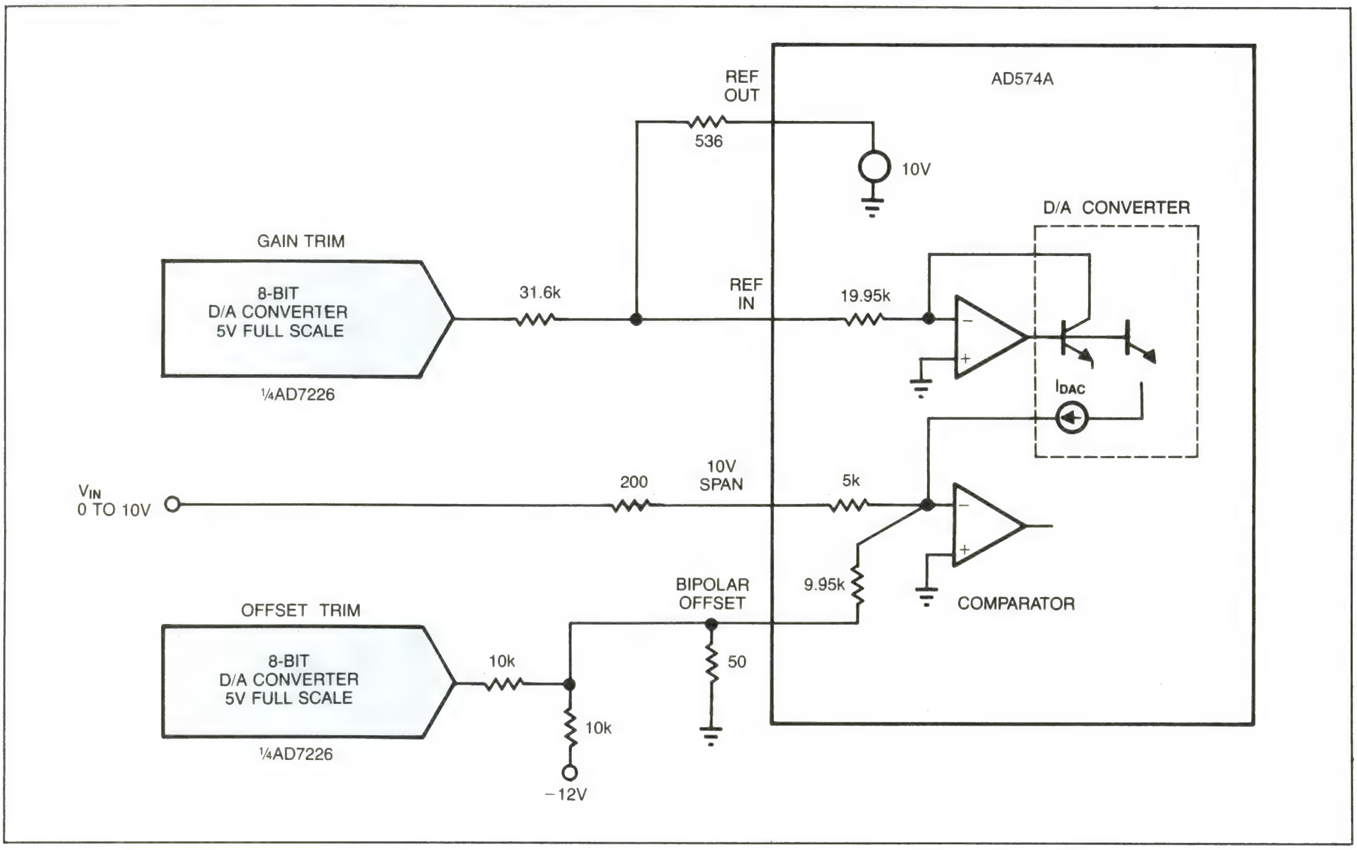


***Fig 10—A software-controlled hardware trimming scheme** uses D/A converters to trim the A/D converter's offset and gain errors. Depending on the software, you could use such a scheme to perform periodic calibration in a data-acquisition system. The attenuators at the outputs of the D/A converters control the resolution of the trim.*

You can trim offset-voltage and gain errors by using either a hardware or software approach; in many systems a combined software-controlled hardware method is best.

deviation from its desired value is stored as the system's offset. Next, the algorithm performs a conversion of a known, near-full-scale analog voltage. This time, the software calculates a gain-correction factor, defined as the input's desired value divided by the converted, measured value less the previously measured offset. The routine trims the digital result from each subsequent conversion by first subtracting the offset and then multiplying by the gain-correction factor.

Clearly, performing these calculations as each conversion's result is retrieved reduces system throughput and limits the system's maximum input frequency. To avoid this loss of speed, you can use a trimming subroutine or a signal-processing algorithm to trim a batch of samples in memory at a later time. Also, if the sampling routine is written in assembly language, the processor can perform the trimming calculations while awaiting the next conversion's completion.

In a system using such software-trimming schemes, the offset and gain errors limit the converter's dynamic range and as a consequence effectively limit its resolution. Assume, for instance, a 0 to 5V signal whose worst-case offset and gain errors (in stages prior to the converter) are ±30%. In the worst case, the input signal can range from a minimum of −1.5V to a maximum of 8V. The A/D converter would need to use a 10V range, offset by −1.5V, to avoid code saturation under worst-case conditions. If the system's gain error is −30%, the 0 to 5V signal would then use only 3.5V of the converter's 10V range. So, under worst-case conditions, only 1434 (35%) of the converter's 4096 codes would span the input range; the converter would therefore offer only 10.5 bits of resolution.

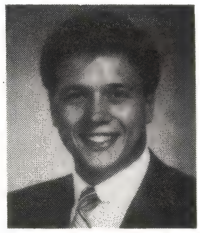
Hybrid trimming schemes become popular

D/A converters used in hybrid combinations of software and hardware trimming have recently become popular for software-controlled calibration **(Fig 10)**. Depending on the trimming range required, an attenuator at the output of a D/A converter of minimal resolution can provide trim resolution of a fraction of the A/D converter's code width. Some sort of iterative comparison algorithm in software can thereby calibrate the A/D converter.

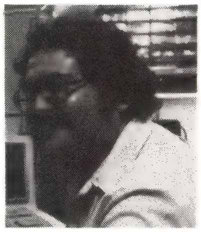
For example, a staircase algorithm might begin by setting the offset-trim D/A converter to half scale (with a near-zero signal applied to the A/D converter) and continue by performing an A/D conversion. Depending on the measured output's digital value relative to the desired value, the algorithm would then increment or decrement the code of the offset-trim D/A converter and repeat the previous steps. This process would continue until the A/D converter's output matches the desired code. The next step is to apply a known, near-full-scale voltage to the A/D converter's input; the algorithm would then manipulate the gain-trim D/A converter to trim the gain error.

The beauty of software-trim D/A-converter schemes becomes evident when you consider the software-controlled application of the two known trimming voltages. If you apply the voltages through two dedicated multiplexer channels, you could use software routines for periodic system calibration. The accuracy of the two known voltages is therefore the only factor limiting the system's offset and gain accuracy over time and temperature. **EDN**

Authors' biographies



John Croteau, a product-marketing specialist at Analog Devices Semiconductor (Wilmington, MA), is engaged in product development for the company's bipolar and BiMOS D/A converters. John holds a BS in engineering science from Penn State University; he's now pursuing an MBA at Boston University. He's an IEEE member.



Doug Grant is new-product marketing manager at Analog Devices Semiconductor, where he's involved in product planning for data converters. Nine years at his present company, he previously worked at Hybrid Systems and Adams-Smith. He's a BSEE graduate from the University of Lowell and an IEEE member. His hobbies are amateur radio and collecting antique radio and electronics books.

Scott Wurcer, a senior design engineer at Analog Devices Semiconductor, has engaged in IC design at the company for the 11 years since he obtained a BSEE degree from Massachusetts Institute of Technology. Scott is an IEEE member.

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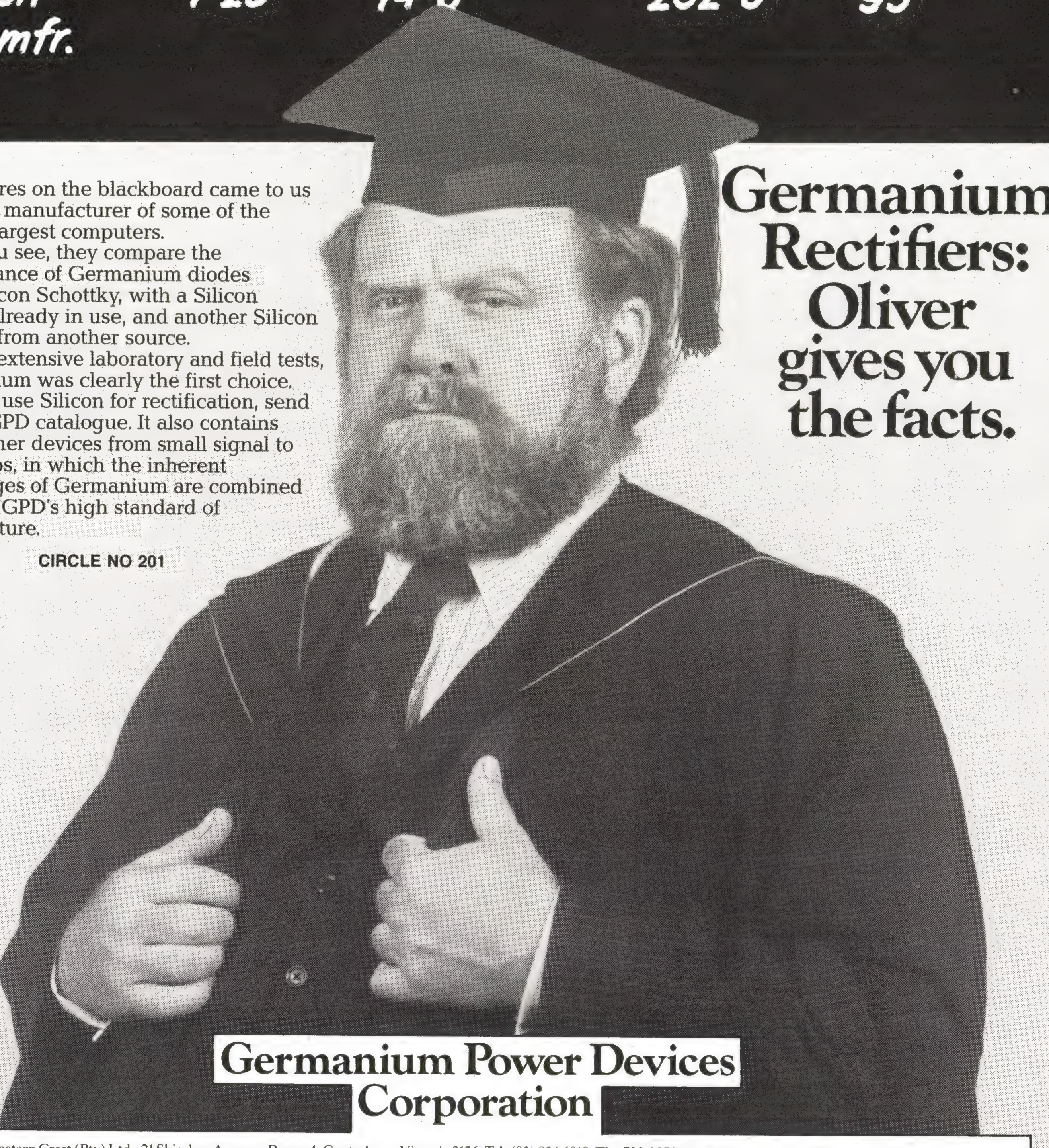


PC-based programs aid analog-circuit design and analysis

You can use analog-circuit simulation software that runs on the IBM PC and compatible computers to analyze circuit designs. The programs, which augment (rather than replace) your circuit-design knowledge, let you analyze a circuit's ac and dc performance and conduct transient, Fourier, and Monte Carlo analyses.

Richard E Kiefer, *Consultant*

Using circuit-simulation programs that run on the IBM PC and compatible computers, you can evaluate analog-circuit designs. Although you'll still need to understand thoroughly the principles of analog-circuit design, the programs can provide additional information and enhance your confidence that your designs will work. These analog-circuit simulation programs let you perform dc and ac analysis, transient analysis, Fourier analysis, and Monte Carlo (worst-case) analysis. Whether you are just starting your design or evaluating its implementation, you'll find these PC-based design tools useful.

Table 1 (pg 188) lists the features and specs of five analog-design software tools. The tools have similar capabilities, so a general description suffices to explain them all. For each type of analysis, one simulation program is described; the description of the analysis, however, holds true for all the packages.

For any type of circuit analysis on a personal computer, you must enter the design into the PC, run an analysis program, and then produce the results of the program in a format that you can understand. In most cases, you enter a design by creating an ASCII input file with a text editor or word processor. Some analysis programs include graphics-input capabilities that let you draw the circuit on the screen by using graphical representations of circuit elements. You then interconnect these elements with lines that represent wires. The program compiles the graphical description into an input file for analysis. To use the file in conjunction with the analysis program, you must identify it as the input file.

After the analysis program has analyzed your input file, you'll want to create output files and graphs to format the results for evaluation. Programs that format analysis results are called postprocessing utility programs; they can plot 2-dimensional graphs with the axes defined in linear or logarithmic steps. If you define the X axis to represent time, the postprocessors create diagrams that are organized like waveforms on a multichannel scope. By setting different zero points and changing the scale of the axes, you can zoom into any part of the plot.

Postprocessing utility programs can plot 2-D graphs with the axes defined in linear or logarithmic steps.

The first step in evaluating your design is dc analysis, which checks the overall biasing voltages of the circuit to verify that resistor values and input common-mode ranges are correct. You can also determine if transistors in your amplifier stages are becoming saturated, if your current sources don't comply with specified ranges, and if your output signals contain nonlinear aberrations caused by inadequate drive capability. You should check all of these conditions over the product's temperature range.

For dc analysis, consider E/Z CAD's Circuitpro program. To use it, you create via a text editor or word processor an ASCII file that describes your circuit. You initiate the analysis by starting the program and submitting the ASCII file from text editor to the Circuitpro program. In this type of analysis, capacitors

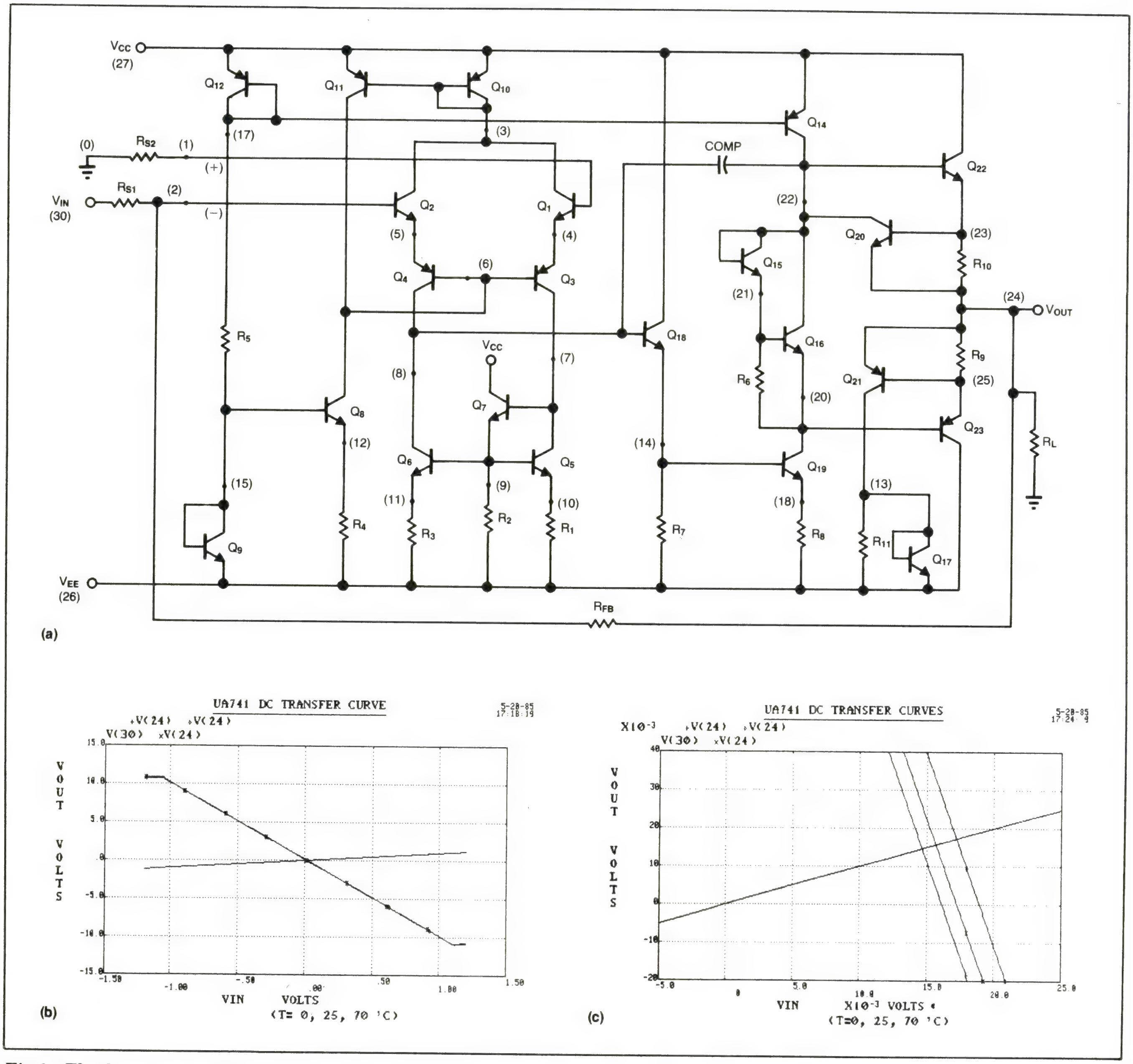
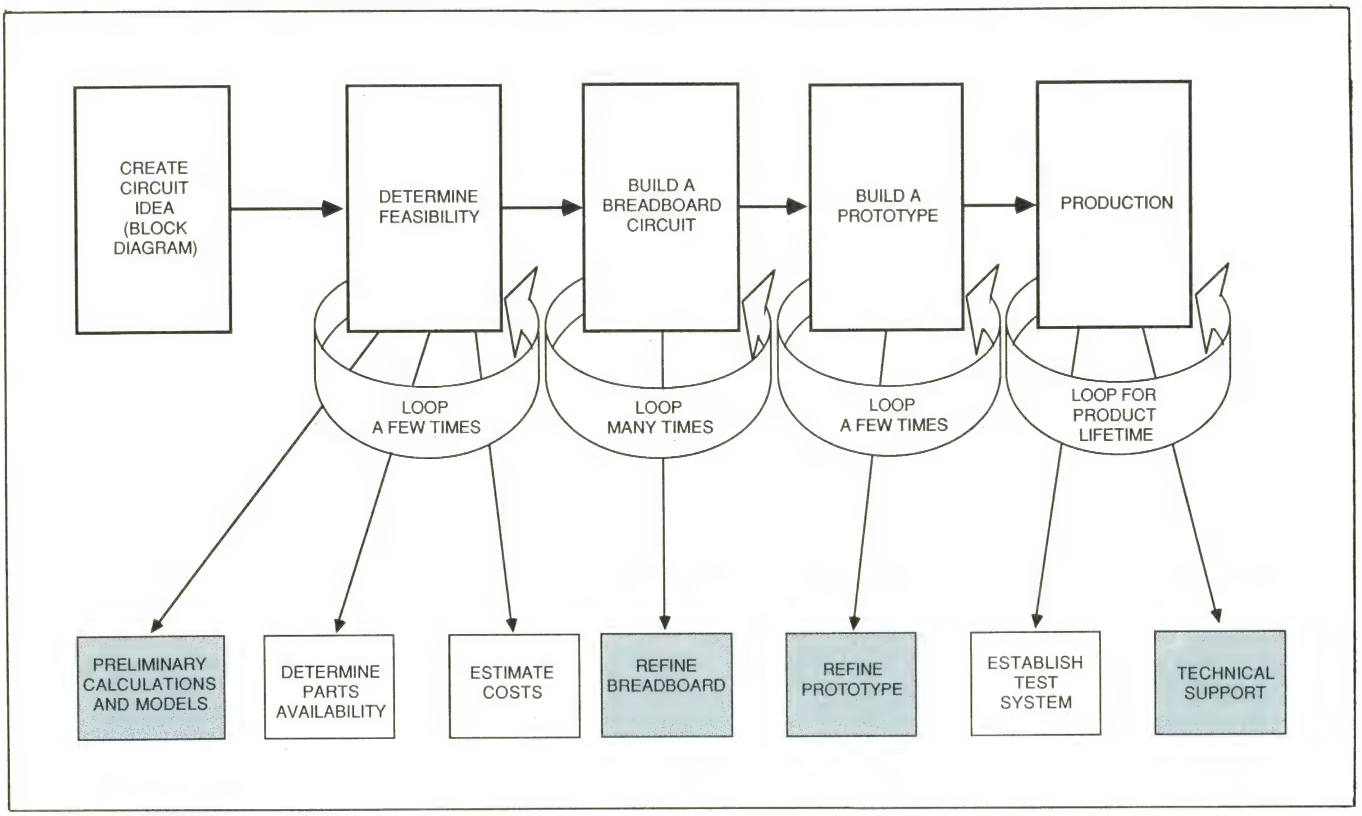


Fig 1—The dc response of an op amp (a) *over its input-voltage range appears in* ***b****. The plot expands in* ***c*** *to show an offset-voltage drift of 30 mV over 0 to 70°C.*



***Simulation assists in several steps** of the analog-design cycle (shaded areas). It performs preliminary calculations, helps analyze breadboard and prototype performance, and supports production.*

appear as open circuits, and inductors have zero resistance.

Upon completion, you plot the results using E/Z CAD's Viewplot program. Viewplot can create plots of simulation waveforms on your PC's screen; to create hard copies, use the MS-DOS Graphics.com utility (by depressing the Shift and Shift-Print keys) to send the image to a printer. Through menus, you can scale the X and Y axes for either scalar or logarithmic units. To create waveform plots that resemble a multichannel-oscilloscope display, use the X axis to designate time. The program allows you to save the scaling data of your plot. Viewplot is a general-purpose plotting program that can plot any data as long as the data is in the output format of Circuitpro.

DC-analysis example

To illustrate the result of Circuitpro's dc analysis, consider the 741 op-amp circuit in **Fig 1a**. You want to examine the output voltage as the input voltage varies from −1.2 to +1.2V, stepped in 400 6-mV increments. To determine the effect of temperature on the output voltage, you can run the 400-step simulation at several temperatures. The results of a simulation run at 0, 25, and 70°C appear in **Fig 1b** and **1c**, plotted at different scales.

The three waveforms nearly overwrite each other in **Fig 1b**. The amplifier drives from a positive rail of approximately +11V to a negative rail of about −11V as the input voltage rises from −1.2 to +1.2V. To see the effect of temperature on the offset voltage, you need to expand the plot in order to get a closer look at the absolute values of the waveforms.

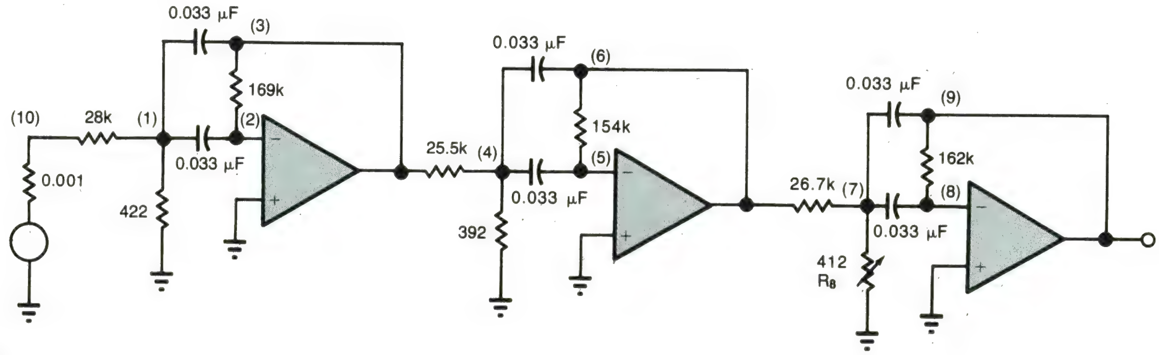
Fig 1c shows the center of the plot of **Fig 1b** with the units changed from volts to millivolts—in essence expanding the resolution of the plot in **Fig 1b**. Viewplot allows you to redefine the units along the X and Y axis to create this expansion. In the expanded version, the voltage for the 0°C plot is roughly 30 mV lower than the voltage for the 70°C plot, indicating that the offset voltage drifts 30 mV over 0 to 70°C.

AC analysis ignores nonlinear responses

The next type of analysis, ac analysis, examines the effects of operating frequency on the amplitude and phase of voltage signals in your circuit. Programs that perform this analysis examine the effect of small ac signals that are juxtaposed on a dc operating point. As a result, this small-signal analysis ignores nonlinear responses that your circuit might exhibit during dc analysis.

You create a description of your circuit in a way similar to that used for the dc-analysis program. You then execute one of the ac-analysis programs such as Acirc from FB Circuit Products. This program allows you to examine any ac node voltage and ac branch current and to calculate Thevenin-equivalent input resistances for the nodes. You can also modify your input file and simulation parameters while you run Acirc without having to use a text editor, and you can save the changes you make.

Fig 2 shows a bandpass-filter schematic in addition to



(a)

```
+ = NODE  9
= INDICATES DOUBLE PLOT IN THAT SPACE
HORIZONTAL UNIT = 2.690E+00 VOLTS.
       .000E+00      I     5.380E+00     I     1.076E+01     I     1.614E+01
           I     2.690E+00     I     8.070E+00     I     1.345E+01     I
           I----:----I----:----I----:----I----:----I----:----I----:----I
5.500E+02 HI              +                                             H
5.520E+02 HI               +                                            H
5.540E+02 HI                 +                                          H
5.560E+02 HI                   +                                        H
5.580E+02 HI                     +                                      H
5.600E+02 HI                       +                                    H
5.620E+02 HI                         +                                  H
5.640E+02 HI                           +                                H
5.660E+02 HI                              +                             H
5.680E+02 HI                                 +                          H
5.700E+02 HI                                   +                        H
5.720E+02 HI                                      +                     H
5.740E+02 HI                                         +                  H
5.760E+02 HI                                            +               H
5.780E+02 HI                                              +             H
5.800E+02 HI                                                 +          H
5.820E+02 HI                                                   +        H
5.840E+02 HI                                                     +      H
5.860E+02 HI                                                       +    H
5.880E+02 HI                                                        +   H
5.900E+02 HI                                                          + H
5.920E+02 HI                                                          + H
5.940E+02 HI                                                           +H
5.960E+02 HI                                                           +H
5.980E+02 HI                                                           +H
6.000E+02 HI                                                          + H
6.020E+02 HI                                                         +  H
6.040E+02 HI                                                        +   H
6.060E+02 HI                                                       +    H
6.080E+02 HI                                                      +     H
6.100E+02 HI                                                    +       H
6.120E+02 HI                                                  +         H
6.140E+02 HI                                                +           H
6.160E+02 HI                                              +             H
6.180E+02 HI                                            +               H
6.200E+02 HI                                          +                 H
6.220E+02 HI                                        +                   H
6.240E+02 HI                                      +                     H
6.260E+02 HI                                   +                        H
6.280E+02 HI                                 +                          H
6.300E+02 HI                               +                            H
6.320E+02 HI                            +                               H
6.340E+02 HI                           +                                H
6.360E+02 HI                         +                                  H
6.380E+02 HI                       +                                    H
6.400E+02 HI                     +                                      H
6.420E+02 HI                    +                                       H
6.440E+02 HI                  +                                         H
6.460E+02 HI                 +                                          H
6.480E+02 HI               +                                            H
6.500E+02 HI              +                                             H
           I----:----I----:----I----:----I----:----I----:----I----:----I
           I     2.690E+00     I     8.070E+00     I     1.345E+01     I
       .000E+00      I     5.380E+00     I     1.076E+01     I     1.614E+01
```

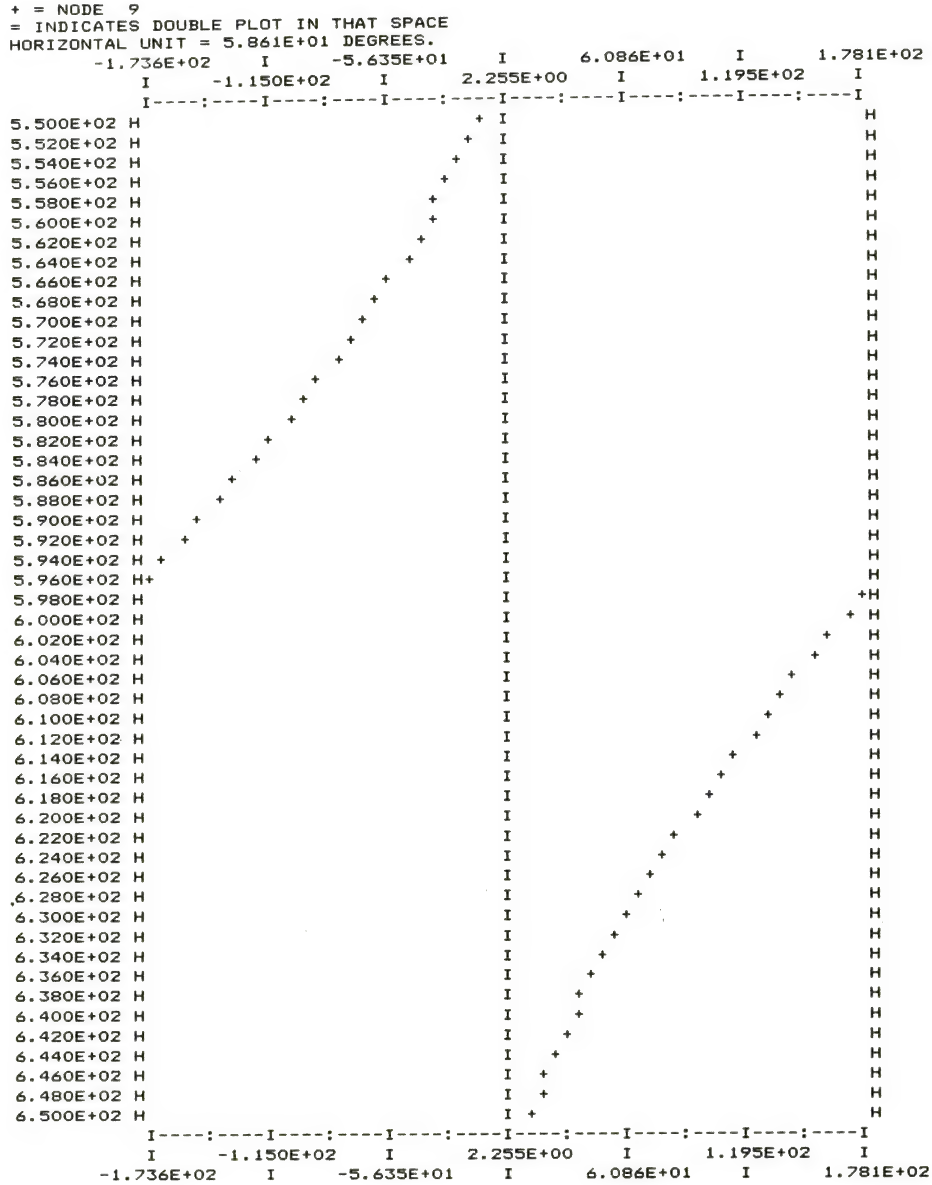
(b)

Fig 2—Acirc, an ac-analysis program, *determines the frequency response of a bandpass filter* ***(a)****; the resulting plots show amplitude* ***(b)*** *and phase* ***(c)*** *response.*

In dc analysis, capacitors appear as open circuits, and inductors have zero resistance.

two plots produced using the Acirc program. The filter uses stagger tuning to isolate a 600-Hz signal; this type of filter is often used in Bell-212A modems to isolate a 600-Hz carrier frequency. Stagger tuning, which reduces the overall temperature drift of the filter, requires you to adjust the value of R_8 to pinpoint the 600-Hz response of the filter (at which point the output signal is exactly 180° out of phase with the input signal at 600 Hz). You use Acirc and estimated values of R_8 to plot the response of the filter and find the best value for R_8.

Figs 2b and **2c** show the output of an ac analysis of the filter in **Fig 2a**. Acirc automatically scales the outputs and can send them to the PC's screen, a disk file, or a printer. You can plot the values of one or two of the nodes in the circuit, and the node's values can be in



(c)

AC analysis ignores nonlinear responses that could appear during dc analysis.

either decibels of gain from the input or in volts. For the filter in **Fig 2a, Fig 2b** shows a maximum output-node voltage of about 16V. The center frequency lies between 596 and 598 Hz. You determine the center frequency by noting the discontinuity in the phase response (**Fig 2c**). To ascertain the center frequency more accurately, you can resimulate the filter using smaller time increments, such as 0.1 Hz, between 596 and 598 Hz.

Transient analysis measures slew rate

Transient analysis (large-scale analysis) can determine such parameters as slew rate, rise time (from which you determine 3-dB bandwidth), overshoot, and settling time, all of which you cannot determine using small-signal ac analysis. Transient analysis looks at the time-domain response of a circuit to an input waveform: usually a step, ramp, or sinusoid. Large input-signal swings induce the nonlinear and reactive behavior of the simulated circuit.

To perform transient analysis using Spectrum Software's MicrocapII program, you enter the circuit, describe the input waveform, set up the parameters of the analysis, and then execute the program. MicrocapII uses graphical entry, and so you use icons to represent such premodeled components as transistors, resistors, capacitors, inductors, diodes, current and voltage sources, and transformers. As you build your circuit on the PC's screen, the program automatically assigns node numbers and displays them on your schematic. You save your completed schematic in a file for input to the simulator.

Program calculates transient circuit values

As an example of MicrocapII at work, consider the analysis of a circuit that uses a step waveform. First, you respond to the program's prompt to insert a model of a pulse generator at the circuit input. You enter such pulse-generator parameters as voltage step, rise time, fall time, and period. Then you specify simulation parameters, including total simulation time over which the program calculates the transient circuit values. You also specify the time step between calculations of circuit values. The program often calculates nodal voltage more frequently than specified by the time step to maintain a minimum accuracy of 5%.

At this time, you can indicate the nodes whose values you want the program to display and the initial values of conditions of components. Assigning initial component values frees you from having to use additional initializing waveforms. For example, if you want a capacitor in your circuit to have a charge on it when the analysis begins, you can simply set the value of that charge.

Program generates output waveforms

As an example of MicrocapII's capability, consider the analysis of a 733-equivalent video amplifier. In **Fig 3a**, the amplifier appears with a pulse generator attached and node numbers assigned. Given the simulation constraints displayed in **Fig 3b**, the transient response appears as shown in **Fig 3c.** Values for V_{CC} and V_{EE} are 6 and -6V, respectively, and R_1 equals 2 kΩ.

The two graphs in **Fig 3c** show the response of the amplifier to a square pulse. The upper plot shows the differential output voltage across the first stage of the amplifier—between nodes 2 and 6. Three output waveforms result from three simulations at different temperatures between 0 and 70°C. The square waveform in the upper plot represents the 80-mV input waveform from the pulse generator. The waveforms on the lower trace show the voltage across R_L. The overshoot and undershoot for all waveforms is evident. In addition, the rise time of the signal from 10 to 90% of its final value is 6 nsec, which corresponds to a 3-dB bandwidth of 58 MHz for the amplifier.

Fourier analysis determines linearity

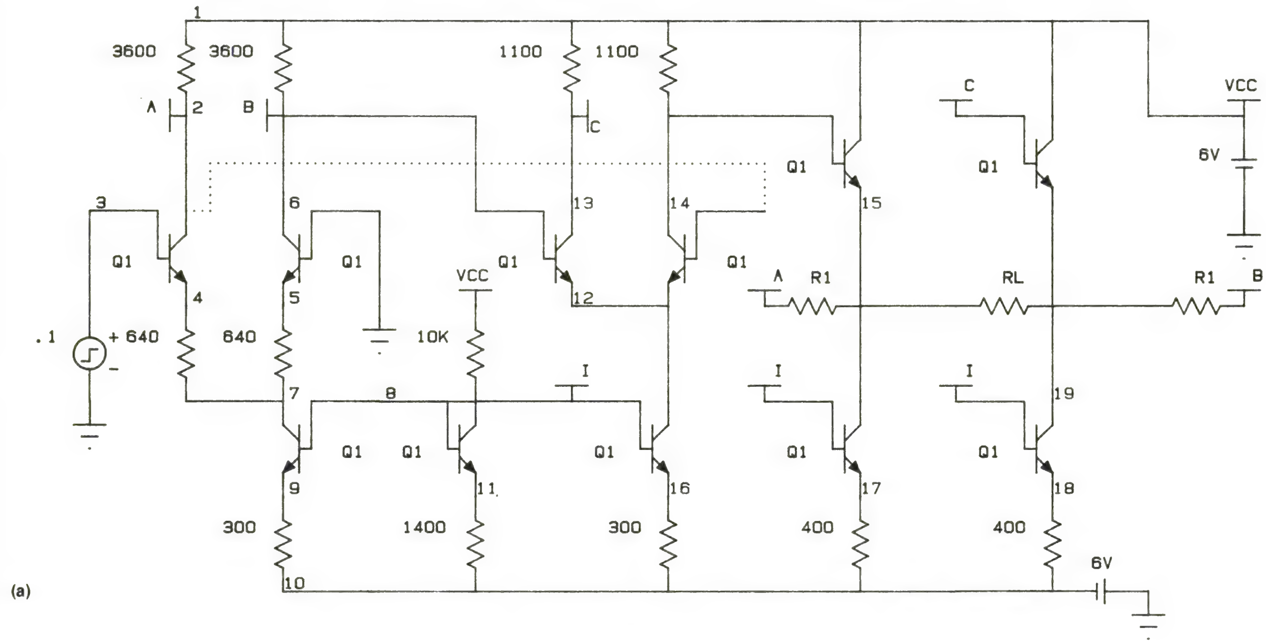
The fourth type of analysis—Fourier analysis—determines the linearity of an analog circuit. In this analysis, you apply an arbitrary waveform to the circuit's input and examine the output waveform for harmonic and intermodulation distortion. You compare the harmonic content of the output with that of the input; when the output differs from the input, the circuit is distorting the waveform.

Like its progenitor, Spice, PSpice from MicroSim Corp requires an input file that contains a description of your circuit and program-analysis commands. The circuit description is similar to a Spice input file, and you can include special active-component model parameters such as the ideal values of the forward and reverse betas and junction capacitance. In addition to commands for controlling the limits of the simulation, you can insert plot and print commands into the input file to direct PSpice to place output data in an intermediate disk file (it's not generally the final file because you'll probably perform postprocessing).

When the simulation is finished, you can use the

Probe postprocessing program to format the output data. Alternatively, you can view the results on your screen or print them directly. Probe allows you to view the data in graphical format, with linear or logarithmic units on the axes. You can expand or contract the scale of the axes as well. Furthermore, you can plot traces of the values at several nodes in your circuit, adding or subtracting traces at will. Because Probe is a general-purpose plotting program, you can use it to create plots from any database that has the same output format as PSpice.

A 5-MHz sinusoidal input to the broadband differen-

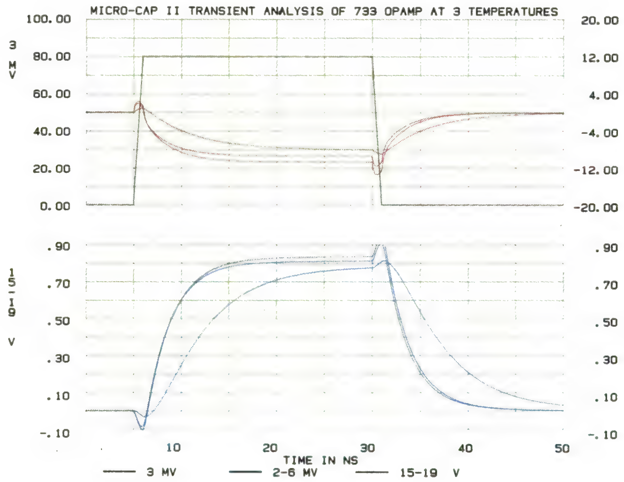


(a)

OP733 ANALYSIS LIMITS

MAXIMUM SIM TIME (SEC)	50E-9
MAXIMUM DELTA TIME (SEC)	.5E-9
MINIMUM ACCURACY (%)	5
UPPER TRACE A	3
UPPER TRACE B	2/6/V
UPPER TRACE RANGE(HIGH/LOW)	.1/0/.02/-.02
LOWER TRACE A	15/19/V
LOWER TRACE B	15/19/V
LOWER TRACE RANGE(HIGH/LOW)	.9/-.1/.9/-.1
ZERO INITIAL CONDITIONS (Y/N)	Y
EDIT/REVIEW INITIAL CONDITIONS (Y/N)	N
DUMP NODE WAVEFORM TO USER FILE (Y/N)	N
CRT PLOT(C) OR TABLE(T)	C
WORST CASE (Y/N)	N
TEMPERATURE (LOW/HIGH/STEP)	25
CALCULATE D.C. OPERATING POINT(Y/N)	Y

(b)



(c)

*Fig 3—**Transient analysis reveals circuit response** to a step or sinusoidal input waveform. For the amplifier in **a,** the analysis limits in **b** result in the plots shown in **c.** Overshoot and undershoot are evident, and the 6-nsec rise time indicates a 58-MHz bandwidth.*

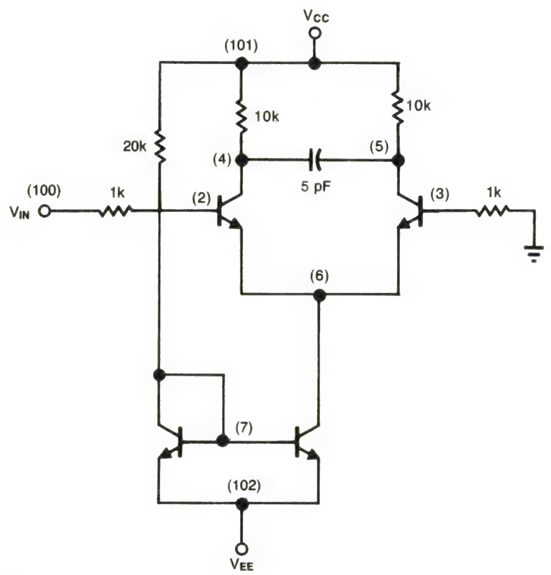
Transient analysis can determine such parameters as slew rate, rise time, overshoot, and settling time.

tial amplifier in **Fig 4a** produces the larger of the two sinusoidal waveforms in the **Fig 4b** Probe plot when run through PSpice. The output waveform appears between nodes 4 and 5 in the schematic. The irregular shape of the output shows the presence of harmonic distortion. PSpice calculates the Fourier analysis of the waveform and presents the results in a tabular format **(Fig 4c)**. The results include the total harmonic distortion as a percentage of the output waveform plus the amplitude and phase of each harmonic component.

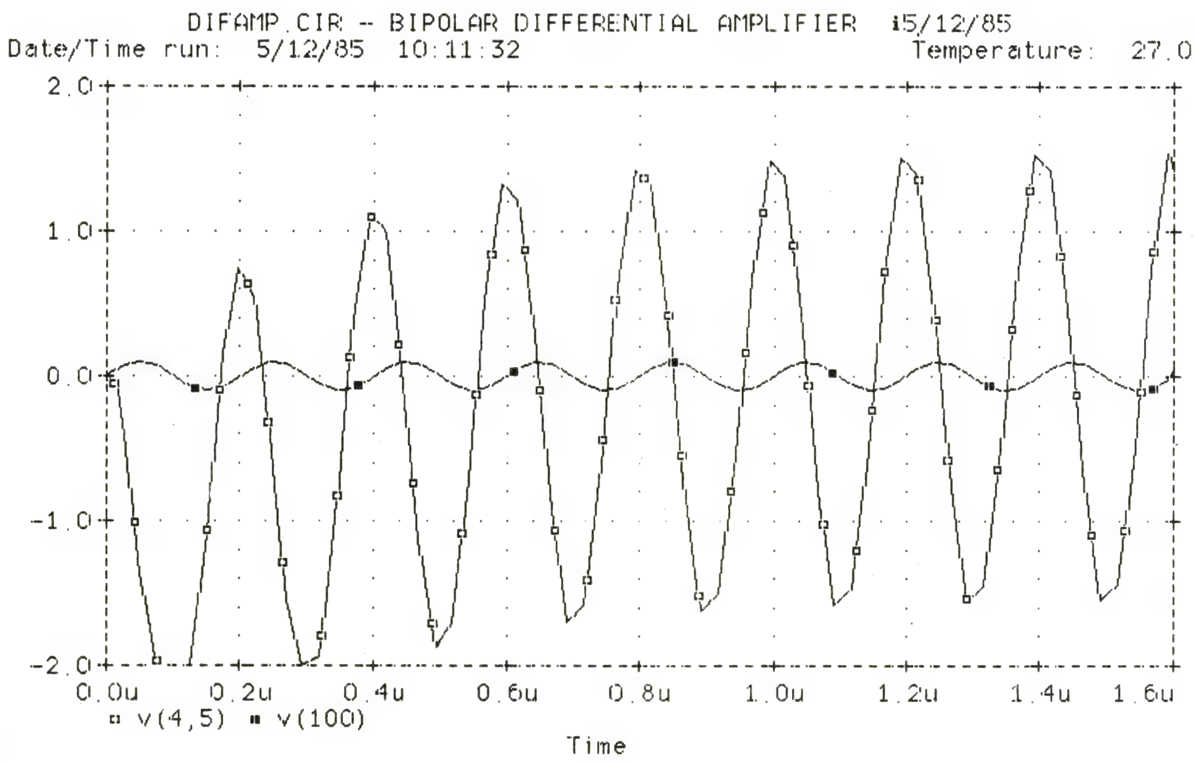
You may also use the PSpice Fourier-analysis capability to construct piecewise-linear or polynomial-shaped waveforms from a current or voltage (or combined) signal. In this way, you can investigate arbitrary input and output waveforms during design.

Consider components' tolerances

The final simulation appropriate to analog-circuit design involves assessing variations in performance that are caused by the tolerances of the components in the circuit. Called Monte Carlo analysis, this simulation



(a)



(b)

Fig 4—A PSpice Fourier analysis of a differential amplifier (a) can be indicated in graphic (b) or tabular (c) form. The tabulation reveals 2.58% total harmonic distortion.

```
******** 5/12/85******** PSpice 2.02 (Mar. 1985)*******10:11:32********

DIFAMP.CIR - BIPOLAR DIFFERENTIAL AMPLIFIER     5/12/85

****     FOURIER ANALYSIS                    TEMPERATURE =   27.000 DEG C

************************************************************************

FOURIER COMPONENTS OF TRANSIENT RESPONSE V(4,5)

DC COMPONENT =  -1.722D-04
```

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	5.000D+06	1.533D+00	1.000000	87.591	.000
2	1.000D+07	5.229D-03	.003410	121.442	33.851
3	1.500D+07	4.699D-03	.003065	95.086	7.496
4	2.000D+07	3.769D-03	.002458	118.711	31.120
5	2.500D+07	3.267D-03	.002131	131.764	44.173
6	3.000D+07	3.817D-03	.002489	128.756	41.165
7	3.500D+07	3.215D-02	.020969	-153.941	-241.532
8	4.000D+07	3.369D-03	.002197	140.577	52.986
9	4.500D+07	2.071D-02	.013505	-160.956	-248.547

```
TOTAL HARMONIC DISTORTION =      2.578233  PERCENT
```

(c)

In Fourier analysis, you apply a sinusoidal signal to your circuit and observe the output waveform for distortion.

indicates whether you can execute your circuit design to meet your specifications, given the tolerances in components and operating conditions.

To run Monte Carlo analysis, you enter a circuit description as you would for ac simulation. Then you enter the tolerances and parasitics of the components you'll use to build the circuit. In the ECA2 program from Tatum Labs, you have the choice of either a text editor or the program's integral circuit editor. Component tolerances and temperature coefficients are part of the component description, but you have to introduce parasitic impedances as additional components. For example, you model a capacitor so that it includes the inductance of the leads.

Analyze a Chebyshev filter

The 10-MHz bandpass filter in **Fig 5a** exhibits a 10-MHz center frequency, a passband ripple of 0.1 dB, and a 3-dB bandwidth of 400 kHz during ac analysis. To analyze this Chebyshev filter, you enter the tolerances and parasitic impedances for the components you'll use to build the circuit. The capacitors will be silver mica

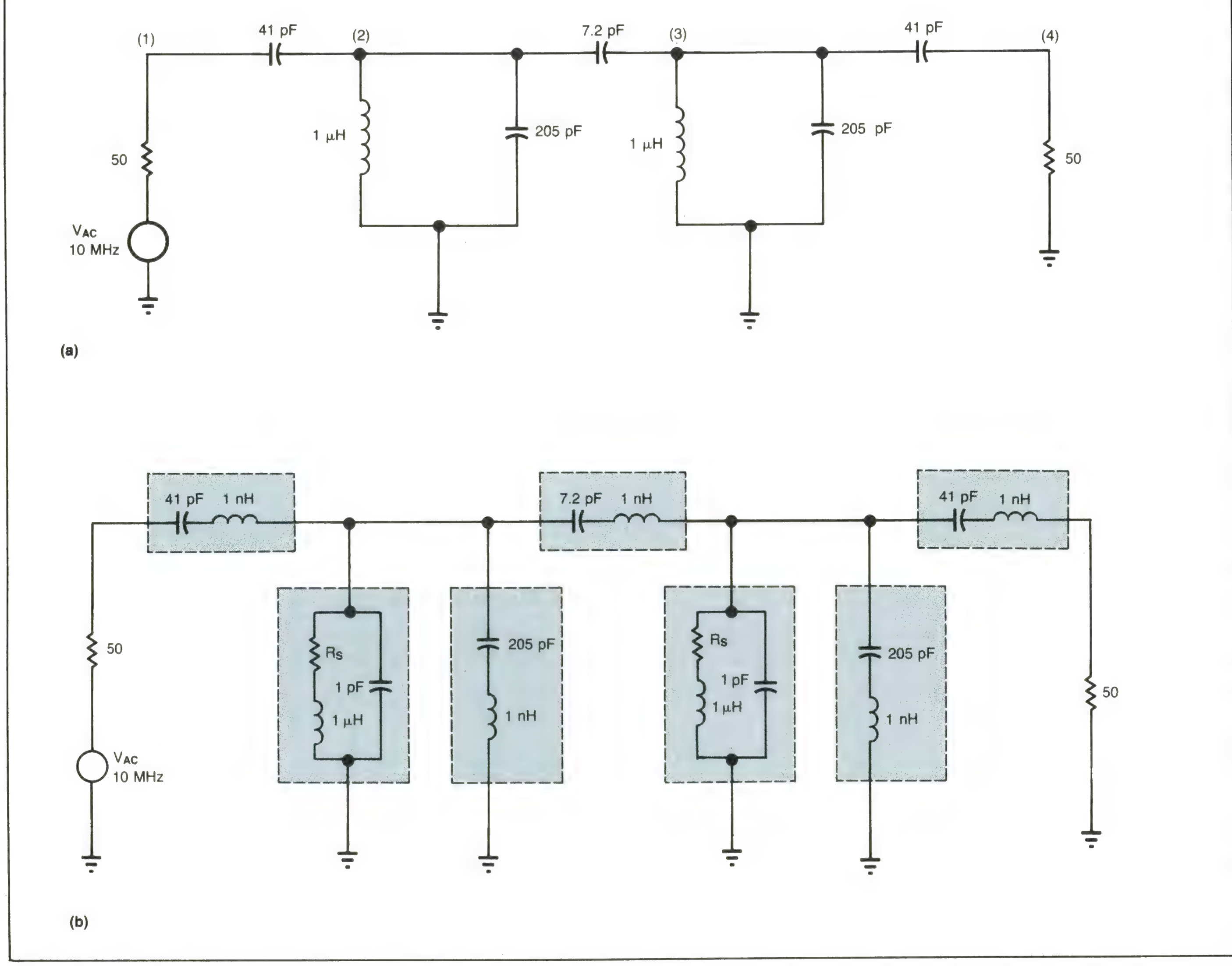


***Fig 5—Monte Carlo analysis** shows mean and standard deviation using several ac-analysis simulations at each frequency. You enter components' tolerances and temperature coefficients for the filter **(a)** into the program, and you model parasitic impedances into the schematic **(b)**. The results of the analysis **(c)** show maximum gain at 9.3 MHz for average production instances of the design.*

```
-->ac 8.2m 10.2m .1m random 10
AC Monte Carlo Analysis
   10 trials          -------- max / min --------   ----- mean / std.dev. -----
 freq        probe    value       dB      phase     value       dB      phase
 8.2M        V:4      0.0085808   -41.329   69.189  0.0078564  -42.130   68.083
                      0.006574    -43.643   67.412  720.47u      0.828    0.573
 8.3M        V:4      0.011381    -38.876   67.854  0.010291   -39.795   66.466
                      0.0084051   -41.509   65.639  0.0010558    0.930    0.718
 8.4M        V:4      0.015516    -36.185   66.242  0.013813   -37.250   64.453
                      0.010946    -39.215   63.403  0.001604     1.058    0.927
 8.5M        V:4      0.021919    -33.184   64.247  0.019133   -34.439   61.856
                      0.014584    -36.722   60.453  0.0025509    1.223    1.245
 8.6M        V:4      0.032483    -29.767   61.697  0.027631   -31.275   58.350
                      0.020004    -33.978   56.338  0.0043064    1.441    1.758
 8.7M        V:4      0.051471    -25.769   58.298  0.042272   -27.629   53.298
                      0.028497    -30.904   50.186  0.0078801    1.743    2.666
 8.8M        V:4      0.089872    -20.928   53.500  0.070275   -23.295   45.270
                      0.042725    -27.386   39.872  0.016108     2.178    4.495
 8.9M        V:4      0.17854     -14.965   46.135  0.1313     -18.005   30.432
                      0.068824    -23.245   19.303  0.03753      2.783    8.913
 9.M         V:4      0.3443       -9.261   33.310  0.25877    -12.171   -1.439
                      0.1227      -18.223  -26.044  0.077761     3.034   20.076
 9.1M        V:4      0.39875      -7.986    6.875  0.35766     -9.026  -50.939
                      0.24299     -12.288  -80.073  0.051995     1.402   29.088
 9.2M        V:4      0.39462      -8.076  -43.718  0.37748     -8.494  -94.525
                      0.29174     -10.700 -118.960  0.031687     0.808   23.857
 9.3M        V:4      0.40417      -7.869  -89.703  0.38226     -8.376 -135.151
                      0.30958     -10.184 -165.665  0.02804      0.687   25.371
 9.4M        V:4      0.40323      -7.889 -125.274  0.32596     -9.864 -179.508
                      0.24617     -12.175  149.160  0.058109     1.576   29.067
 9.5M        V:4      0.38734      -8.238 -169.760  0.22181    -13.541  144.853
                      0.1416      -16.979  125.523  0.079466     2.926   20.670
 9.6M        V:4      0.2562      -11.828  149.122  0.13665    -17.757  123.924
                      0.090058    -20.910  113.551  0.051356     2.901   11.204
 9.7M        V:4      0.15373     -16.265  126.780  0.088801   -21.366  112.688
                      0.062937    -24.022  106.536  0.027951     2.456    6.413
 9.8M        V:4      0.1004      -19.965  114.981  0.062806   -24.276  106.035
                      0.047086    -26.542  101.931  0.016426     2.077    4.160
 9.9M        V:4      0.071334    -22.934  107.915  0.047431   -26.654  101.642
                      0.037015    -28.632   98.664  0.010582     1.796    2.963
 10.M        V:4      0.053966    -25.358  103.223  0.037578   -28.637   98.508
                      0.030197    -30.401   96.214  0.0073325    1.587    2.252
 10.1M       V:4      0.042768    -27.378   99.871  0.030859   -30.322   96.146
                      0.025353    -31.919   94.302  0.0053731    1.427    1.794
 10.2M       V:4      0.035108    -29.092   97.349  0.026054   -31.773   94.295
                      0.021778    -33.240   92.763  0.0041127    1.302    1.480
```

(c)

For Monte Carlo analysis, you construct several circuits on the computer without building any actual hardware.

Glossary of analog-circuit simulation terms

AC noise contributions—the relative amplitude of signal noise at a node in a circuit caused by noise sources within the circuit.

AC transfer characteristic—the relative gain, phase, or delay of the signal at a node with respect to a reference node. The term also refers to absolute measurement of ac voltage, current, or power at a particular frequency.

AC voltage/phase/delay sensitivity—relative response of a node's voltage, phase, or delay at a particular frequency to a change in some device parameter.

Arbitrary-programmed voltage or current source—an ideal source whose output you can describe in any mathematical or tabular form.

Component macro model—a user-defined collection of circuit elements that performs a specific function.

Current-controlled current source (CCCS)—an ideal current source whose output current is a linear function of an input current.

Current-controlled voltage source (CCVS)—an ideal voltage source whose output is a linear function of an input current.

DC quiescient bias condition—the values of all node voltages, currents, and power dissipations in a circuit, taking into account the nonlinearities of solid-state components in the circuit.

DC transfer characteristic—the response of a circuit to dc operating conditions and inputs with all reactive components eliminated (capacitors are open circuits, inductors are short circuits).

DC voltage/current sensitivity—the relative response of a node voltage or branch current to a change in some device parameter.

Fourier response—the magnitude of harmonic frequencies in the output signal of a circuit. The signal can be voltage, current, or power.

Independent current source—an ideal current source with infinite output impedance and infinite voltage compliance.

Independent voltage source—an ideal voltage source with zero output impedance and infinite current capability.

Monte Carlo statistical analysis—an analysis technique that determines the mean and standard deviation of circuit response. It requires many simulations using ac, dc, or transient analysis in which the component parameters are selected randomly from specified ranges of values.

Piecewise linear voltage or current source—an ideal source that has different gains at opposite input polarities or at different frequencies, with intermediate polarities and frequencies interpolated linearly.

Polynomial voltage or current source—an ideal source whose output is a polynomial function of an input voltage.

Programmable voltage or current source—an ideal source whose output you can program, eg, a pulse generator.

Random-parameter evaluation—an ac, dc, or transient-response calculation based on a random selection of component values from a uniformly distributed set of possible values.

Temperature analysis—the output of a circuit calculated as a function of temperature, determined by including temperature coefficients.

Transient response—the response of a circuit to one or more changing input sources, taking into account nonlinear behavior of solid-state devices and reactive components.

Voltage-controlled current source (VCCS)—an ideal current source whose output current is a linear function of an input voltage.

Voltage-controlled voltage source (VCVS)—an ideal voltage source whose output voltage is a linear function of an input voltage.

Worst-case parameter evaluation—an ac, dc, or transient analysis in which you vary the values of components within their tolerance ranges to produce the widest fluctuation in output.

For more information . . .

For more information on the analog-circuit simulation programs described in this article, circle the appropriate numbers on the Information Retrieval Service card, or contact the following manufacturers directly.

E/Z CAD Inc
5589 Starcrest Dr
San Jose, CA 95123
(415) 582-2009
Circle No 534

Spectrum Software
1021 S Wolfe Rd
Sunnyvale, CA 94087
(408) 738-4387
Circle No 537

FB Circuit Products Inc
5234 Longfellow Way
Oxnard, CA 93033
(805) 986-2276
Circle No 535

Tatum Labs
Box 698
Sandy Hook, CT 06482
(203) 426-2184
Circle No 538

MicroSim Corp
23175 La Cadena Dr
Laguna Hills, CA 92653
(714) 770-3022
Circle No 536

devices that exhibit a temperature coefficient of 50 ppm/°C, a 5% tolerance, and a series lead inductance of 1 nH. The inductors, built from #6 material wound around a T-50-6 iron core, demonstrate a temperature coefficient of 35 ppm/°C, a stray parallel capacitance measuring 1 pF, and a 10% tolerance. The value of Q for the inductors varies from 170 at 4 MHz to 205 at 12 MHz. The program uses the value of Q to calculate the equivalent series resistance R_S of the inductor for each analyzed frequency. For frequencies between 4 and 12 MHz, the program calculates R_S using a straight-line interpolation shown in the equation $R=2\pi fL/Q$, where f is frequency and L is the inductance measured in henrys.

The results of the analysis at each of the sample frequencies appears in **Fig 5c.** The first column on the left lists the frequency of the simulation, and the second column shows the node sampled. The middle three columns show the maximum and minimum gain of the circuit as measured at the frequency on the left. To determine the effect of variations in component values at each frequency, the program randomly selects values for the components within the components' listed tolerances and simulates the circuit 10 times. The filter has its highest mean gain at 9.3 MHz, which is the average center frequency if you use the components detailed in the previous paragraph. Minimum and maximum values tell you the widest range of responses you can expect when you start building the filter.

The program also lists the mean and standard deviations in the frequency response in the right-hand columns in **Fig 5c.** The program calculates the variations over the 10 simulations. At 9.3 MHz, the mean value of the circuit's attenuation is −8.376 dB with a standard deviation of 0.687 dB. Therefore, 68% of the filters built with these components will demonstrate an attenuation of −8.376±0.687 dB at their 9.3-MHz center frequency. **EDN**

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3. Nagel, Lawrence, "Spice: A Computer Program to Simulate Semiconductor Circuits," EECS Industrial Liaison Program, Memorandum No ERL-M520, University of California, Berkeley, CA.
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Author's biography

Richard E Kiefer is an independent design consultant for analog, RF, and EMI electronics. Based in Boulder, CO, he has worked with Martin Marietta, IBM, Hewlett-Packard, and Armco Autometrics. He holds BSEE and MSEE degrees from the Lawrence Institute of Technology and the University of Colorado. His hobbies include listening to classical music, operating a ham radio, cross-country skiing, backpacking, Scandinavian folk dancing, and reading historical novels.

Article Interest Quotient (Circle One)
High 476 Medium 477 Low 478

TABLE 1—FEATURES OF REPRESENTATIVE ANALOG-CIRCUIT-SIMULATION SOFTWARE PACKAGES

	E/Z CAD INC's CIRCUITPRO v 2.02 AND VIEWPLOT v 1.0	FB CIRCUIT PRODUCTS' DCIRC, ACIRC, AND TCIRC v 1.3	MICROSIM CORP's PSPICE v 2.02 AND PROBE v 1.0	SPECTRUM SOFTWARE's MICROCAPII v 2.0	TATUM LABS' ECA2 v 2.04
CIRCUIT ANALYSIS TYPES					
DC-TRANSFER CHARACTERISTICS	•		•	•	•
DC QUIESCIENT BIAS CONDITION	•	•	•	•	•
DC VOLTAGE/CURRENT SENSITIVITIES	•	•	•		•
AC-TRANSFER CHARACTERISTICS	•	•	•	•	•
AC-NOISE CONTRIBUTIONS	•		•		
AC-VOLTAGE/PHASE/DELAY SENSITIVITIES					•
TRANSIENT RESPONSE	•	•	•	•	•
FOURIER RESPONSE	•		•	•	
WORST-CASE PARAMETER EVALUATION					•
RANDOM-PARAMETER EVALUATION				•	•
MONTE CARLO STATISTICS					•
TEMPERATURE-VARIATION EVALUATION	•		•	•	•
DC-COMPONENT OPTIMIZATION		•			
PARAMETER SWEEPS					
LINEAR	•	•	•	•	•
LOGARITHMIC	•	•	•	•	•
BY MULTIPLIER		•			•
COMPONENTS (BUILT-IN MODELS)					
PASSIVE					
RESISTOR	•	•	•	•	•
CONDUCTANCE ELEMENT				•	•
CAPACITOR	•	•	•	•	•
INDUCTOR	•	•	•	•	•
TRANSFORMER	•	•	•	•	•
TRANSMISSION LINE	•		•	•	•
SWITCH				•	•
NONLINEAR CHARACTERISTIC					•
SEMICONDUCTOR					
DIODE	•	•	•	•	•
BIPOLAR TRANSISTOR	•	•	•	•	
JFET	•	•	•		
MOSFET	•		•	•	
OP AMP		•		•	•
POWER SOURCES					
BATTERY				•	•
INDEPENDENT VOLTAGE SOURCE	•	•	•	•	•
VCVS	•		•	•	•
VCCS	•		•	•	•
INDEPENDENT CURRENT SOURCE	•	•	•	•	•
CCVS	•		•	•	
CCCS	•		•	•	
PROGRAMMABLE				•	•
POLYNOMIAL	•		•	•	•
PIECEWISE LINEAR					•
ARBITRARY				•	
CIRCUIT MACRO MODELS	•		•	•	•

Continued on pg 190

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	E/Z CAD INC's CIRCUITPRO v 2.02 AND VIEWPLOT v 1.0	FB CIRCUIT PRODUCTS' DCIRC, ACIRC, AND TCIRC v 1.3	MICROSIM CORP's PSPICE v 2.02 AND PROBE v 1.0	SPECTRUM SOFTWARE's MICROCAPII v 2.0	TATUM LABS' ECA2 v 2.04
COMPONENT-MODEL LIBRARY AVAILABLE			•	•	
OPERATOR INPUTS					
CIRCUIT DESCRIPTION					
BATCH DISK FILE	•	•	•	•	•
ONLINE KEYBOARD					•
CRT SCHEMATIC				•	
CIRCUIT CHANGES					
BATCH DISK FILE	•	•	•	•	•
ONLINE KEYBOARD		•			•
CRT SCHEMATIC				•	
ANALYSIS COMMANDS					
BATCH DISK FILE	•		•		•
KEYBOARD		•		•	•
SIMULATOR OUTPUTS					
DISK DATA FILE	•		•	•	•
PRINTER DATA	•	•	•	•	•
PRINTER GRAPHS	•	•	•	•	•
CRT-SCREEN DATA	•	•	•	•	•
CRT-SCREEN GRAPHS	•	•	•	•	•
PLOTTER GRAPHS			•	•	
PLOTTER SCHEMATICS				•	
ONLINE HELP		•		•	•
8087-COPROCESSOR SUPPORT AVAILABLE	•	•	•		•
HARDWARE ACCELERATOR AVAILABLE			•		
FULL NONLINEAR CALCULATIONS	•		•	•	•
APPROXIMATE MAX CIRCUIT SIZE					
NODES, DC ANALYSIS		40		100	500
NODES, AC ANALYSIS		40		50	500
NODES, TRANSIENT ANALYSIS		40		100	500
NET-LIST ITEMS				256	2500
TRANSISTORS	120		120		
LANGUAGE	FORTRAN	FORTRAN	FORTRAN	BASIC	COMPILED C
COPY PROTECTION	•		•		
MINIMUM SYSTEM REQUIREMENTS					
MEMORY (BYTES)	512k	192k	512k	256k	256k
FLOPPY DISKS	1	1	1	1	1
OPERATING SYSTEM	DOS 2.0	DOS 1.1	DOS 2.0	DOS 1.1	DOS 2.0
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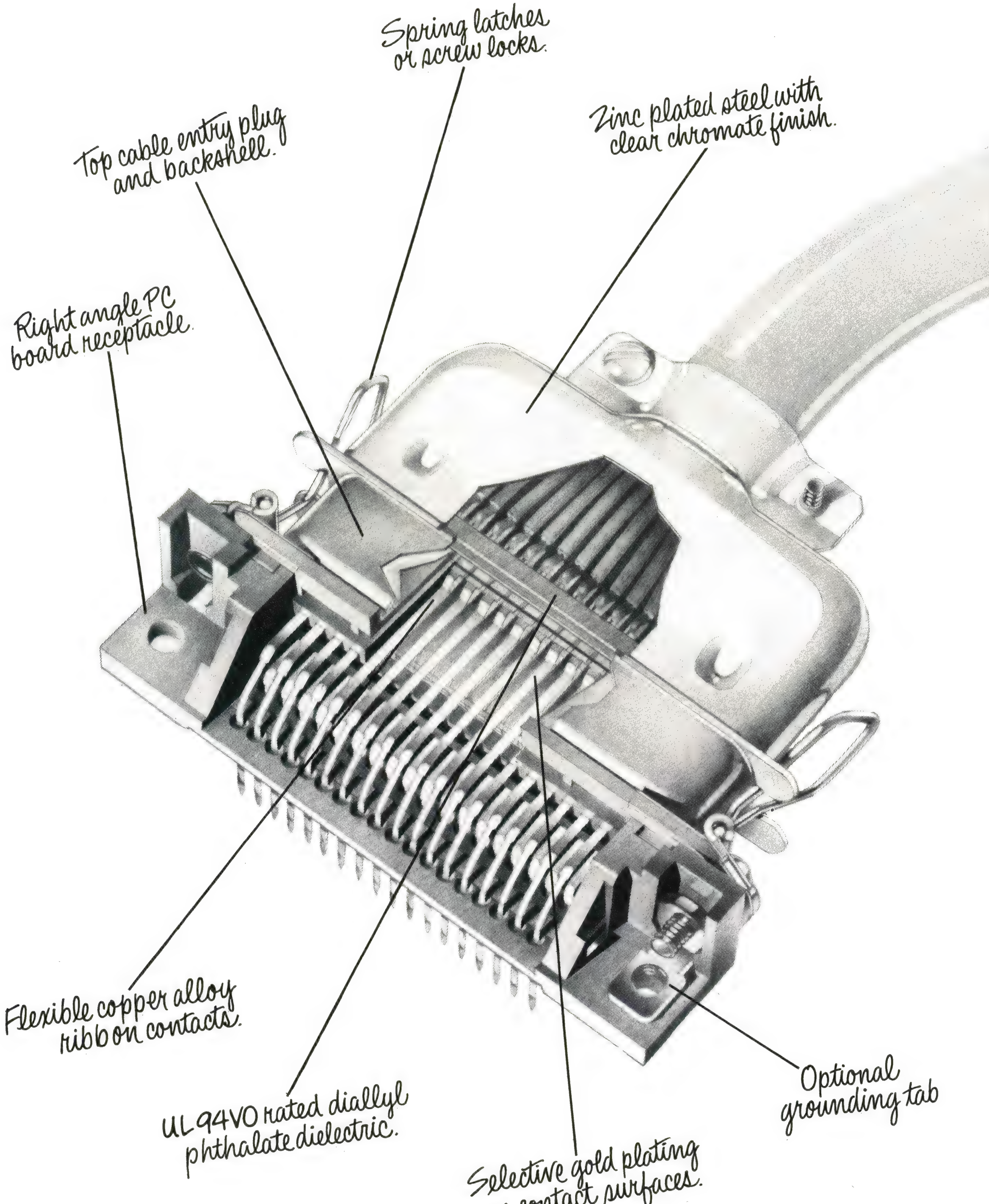
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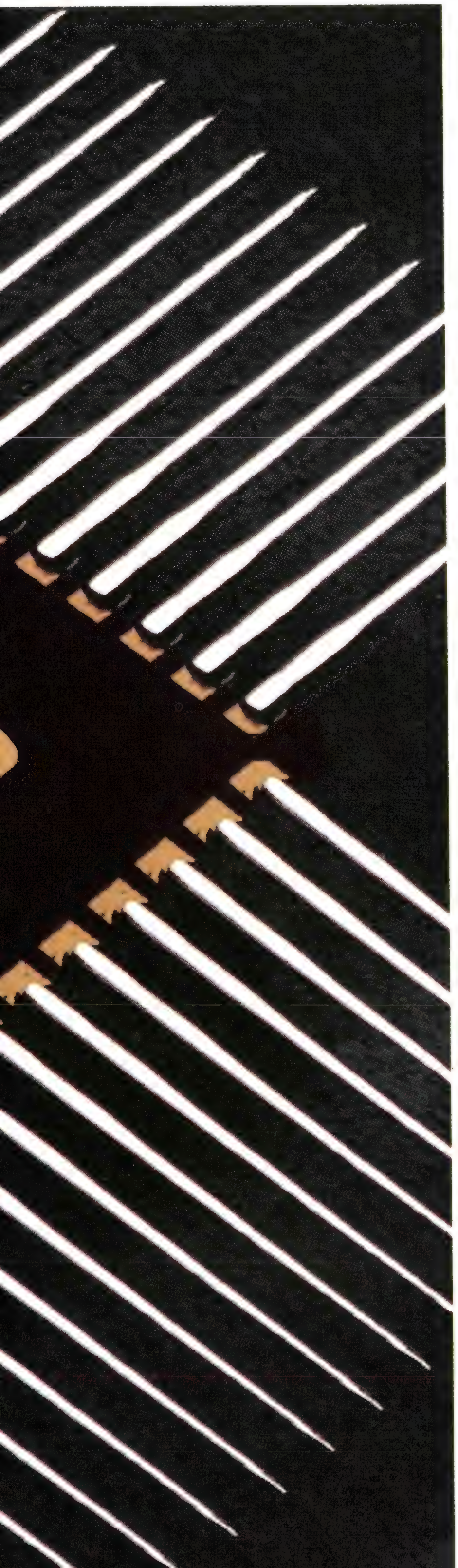

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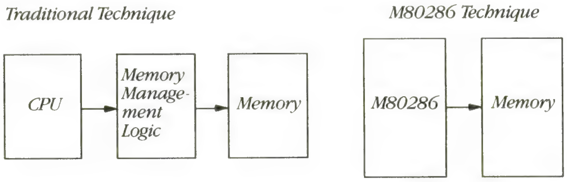

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Don Faria, *Altera Corp*

New erasable programmable-logic devices (EPLDs) contain several design features that now let you implement sequential circuits in addition to combinatorial circuits. Among these features are AND arrays for combinatorial logic, programmable output cells for flip-flops and drivers, and feedback paths. The programmable feedback and output features enhance the basic product-term array common to many PLDs, allowing the EPLD to implement such noncombinatorial circuits as counters and state machines. An implementation of an EPLD as a motor controller illustrates the use of EPLD features.

Of course, before you decide that your design is a suitable candidate for an EPLD, you must determine whether a sufficiently large EPLD exists to support your design. EPLDs come in many sizes, varying in the number of inputs, outputs, product terms, and macrocells available. You first compare your I/O, flip-flop, and clock-frequency requirements with the specifications of available devices. If you find an EPLD that looks promising, you then attempt to complete the design using PLD-design software. This software attempts to compile your design into EPLD code. When you have corrected any design errors identified by the compiler, the EPLD can implement your design. Design compilation takes minutes, so you can attempt several iterations of your design in pursuit of a fit to a particular EPLD.

EPLD circuitry consists of macrocells that contain an AND/OR array, output and feedback selection, and interconnecting signals. The AND/OR array consists of input signals that form product terms (AND gates) connected to an OR gate. An EPLD designer creates the pattern in each macrocell that realizes the desired logic function. The designer switches an interconnecting transistor by applying a charge to the transistor's floating gate, and this action controls the connection between an input signal and a product term. Typical EPLDs have 18 to 64 inputs and 74 to 480 product terms.

EPLD I/O circuitry contains a flip-flop, feedback, and output-selection circuitry. You program outputs from the logic array so that they connect to the macrocell I/O architecture. The macrocell I/O can store the values of the logic array and also drive the value back into the logic array via feedback circuitry. You can also program the macrocells to drive values to output pins via output circuits.

The motor-positioning circuit shown in **Fig 1** illustrates how a logic design can employ the macrocell circuits of an EPLD. The motor controller is called an X-Y positioner because, in a 2-D plane of motion, it

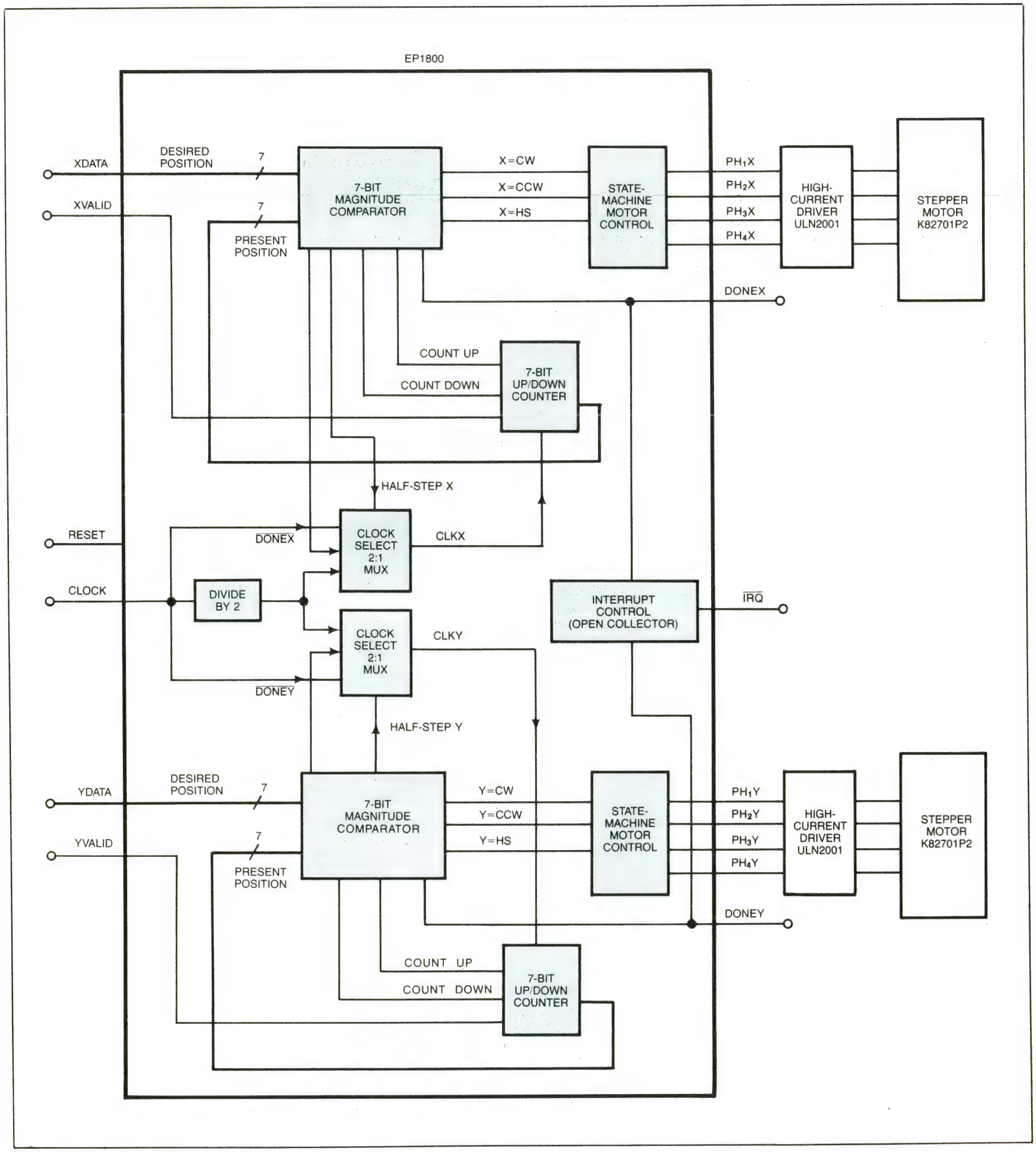


Fig 1—An EPLD implementation of a motor-positioning circuit *illustrates the use of many features of the EPLD. The circuit compares desired stepper-motor coordinates with actual coordinates and generates the appropriate signals to drive the motors to the desired coordinates. The EPLD's logic plane, feedback features, and output selection can implement all of the circuitry of the positioner on one chip.*

The feedback macrocell features enhance the basic logic array to implement such non-combinatorial circuits as counters and state machines.

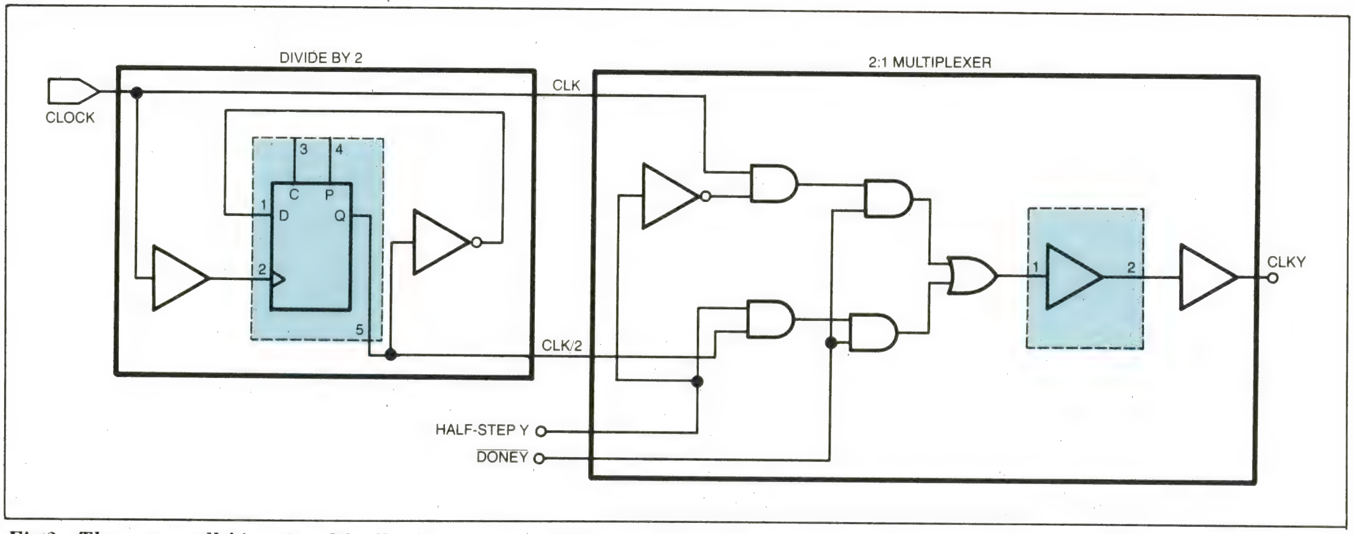


Fig 2—The macrocells' input and feedback options, *exploited in this clock circuit, allow you to connect an input directly to a macrocell and to feed back a macrocell output to the EPLD's logic array. This figure shows the Y-axis clock circuit; the X-axis clock circuit is identical.*

controls one motor on the X axis and one on the Y axis. The positioner accepts inputs, from a μP, that describe the desired X and Y coordinates, and it also determines the necessary action of the motors. It then drives control signals to two 4-phase stepper motors to achieve the new position. In addition, the positioner requires a 500-Hz clock input and a reset signal to indicate the initial "0,0" position.

The positioner circuit in this example is an Altera EP1800 EPLD (see **box,** "Programmable macrocells yield flexible EPLDs"). The positioner drives the two stepper motors through ULN2001 high-current drivers. The drivers convert the controller's TTL-level outputs to the drive signals required for the motor control. The stepper motors, Airpax K82701P2s, step in 7.5° increments. To implement full and half steps, the controller must designate 96 distinct motor positions for each axis. To distinguish 96 positions, the minimum number of control bits for the X and the Y axes is seven ($2^7=128$).

In addition to motor-control signals, the controller furnishes two outputs, DONEX and DONEY, that indicate when the positioner has driven the motors to the desired X and Y coordinates, respectively. When this action is complete, the interrupt output ($\overline{\text{IRQ}}$) sends signals to the system controlling the positioner. The positioner is then ready to accept the next set of desired coordinates.

Within the controller, two identical logic circuits keep track of the positioner's actual coordinates, compare the actual and desired coordinates, and translate the required movement into the appropriate 4-phase stepper-motor signals. A clock circuit supplies a 500-Hz clock signal for full-step movement and a 250-Hz clock signal for half-step movement.

Fig 2 shows the Y-axis clock circuitry in the position controller (the X-axis clock circuit is identical). The circuitry consists of divide-by-2 logic and a 2:1 multiplexer. The clock signals drive the flip-flops in the controller's up/down counter. In half-step mode, the 250-Hz clock signal slows the change of position reflected in the counter compared with the rate of change dictated by the 500-Hz clock. At any given time, the multiplexer routes one of the two clock signals to the counter, depending on whether the controller is in half-step or full-step mode.

Macrocells make versatile clock circuit

The clock circuitry exploits two features of the EPLD's macrocells: Inputs to macrocells can be chip inputs or internal feedback paths, and the macrocells can drive signals back into the logic plane. (The solidly lined boxes in **Fig 2** show EPLD macrocells.) The clock input comes straight into the divide-by-2 circuit's macrocell through the logic plane. Alternatively, you could connect the signal with other signals via an AND gate to create a composite clock. The circuit routes the output of the divide-by-2 flip-flop back into the logic plane to form one of the clock inputs (CLK/2) to the multiplexer. The output also feeds back through an inverter to the D input of the flip-flop.

The multiplexer logic, unlike the divide-by-2 logic,

Text continued on pg 207

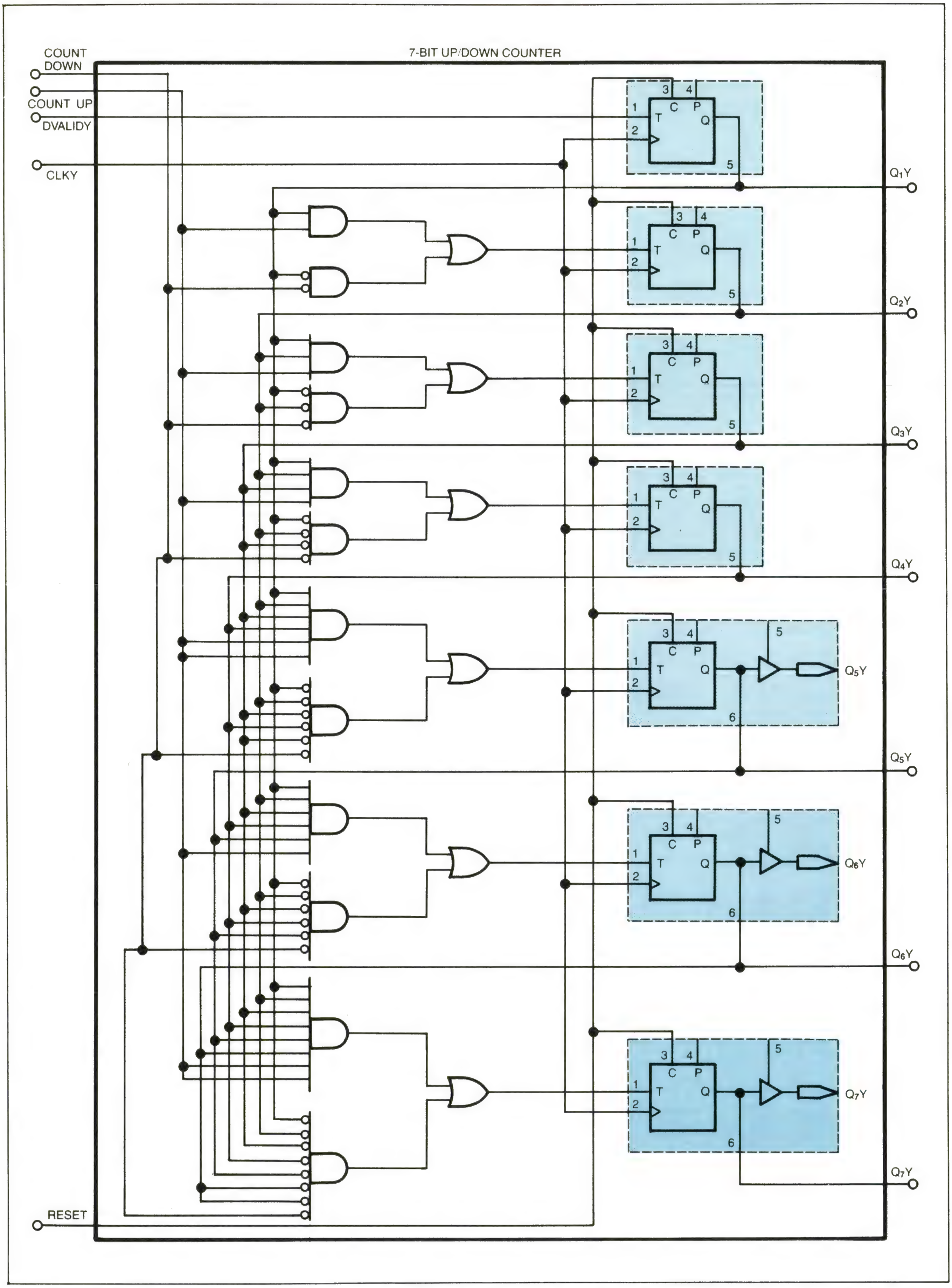


*Fig 3—**Using the logic arrays in the macrocells,** the positioner's up/down counters store the present position of the stepper motor. When the comparator drives the motor to a new position, it updates the counter by asserting the count-up or count-down signals.*

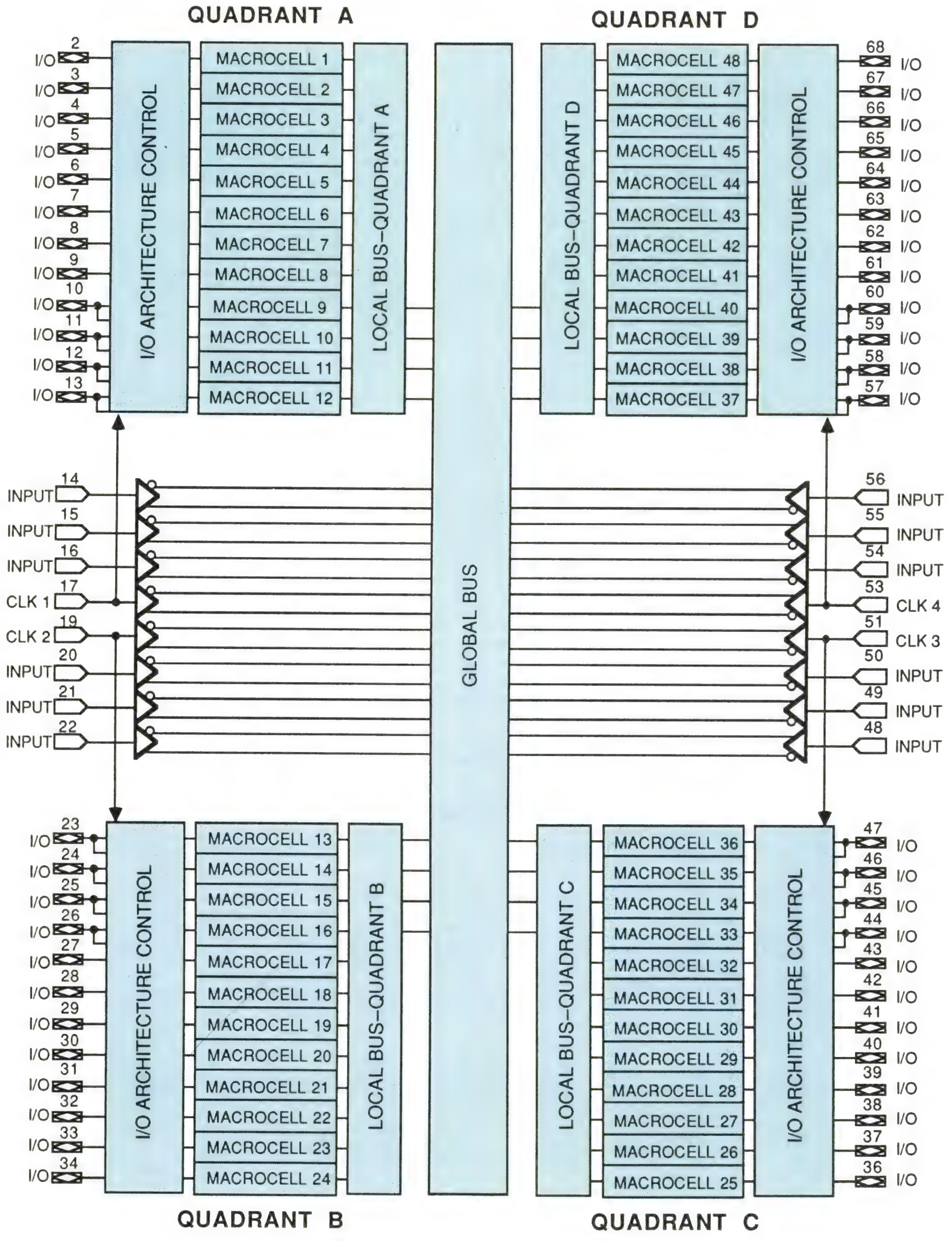


Fig A—Buses, macrocells, and I/O control logic *combine to form the EP1800 architecture. All inputs travel to all macrocells through the global bus; macrocells contain logic arrays and storage elements. Feedback within quadrants occurs via the local bus and global bus. Feedback and output circuits reside in the I/O-architecture control logic.*

Programmable macrocells yield flexible EPLDs

The EP1800 EPLD comprises a logic array and programmable macrocells. It contains circuitry that's equivalent to approximately 2100 2-input gates, a degree of complexity normally associated with gate arrays. In addition to having an order of magnitude more logic than traditional 20- and 24-pin fuse programmable bipolar PLDs, the EP1800 includes programmable features that make it more flexible than the bipolar PLDs for implementing general-purpose logic circuits:

- Transition-sensitive input circuits allow the internal circuitry of the device to remain in a quiescent mode when the inputs aren't changing. The quiescent mode consumes less power than circuits that are continuously in an on state.
- You can program each of the EP1800's 48 macrocells to operate as a D, J-K, set-reset, or T flip-flop.
- You can program the macrocells to implement a variety of feedback paths. Sixteen of the macrocells can implement two feedback paths, providing both a flip-flop and a connection to an input pin.
- You can program the chip's four clock circuits for synchronous or asynchronous operation.
- Some macrocells provide feedback paths to nearby macrocells, and some macrocells provide feedback to all macrocells. The global feedback helps to minimize the propagation delay required when one signal must drive all of the macrocells.

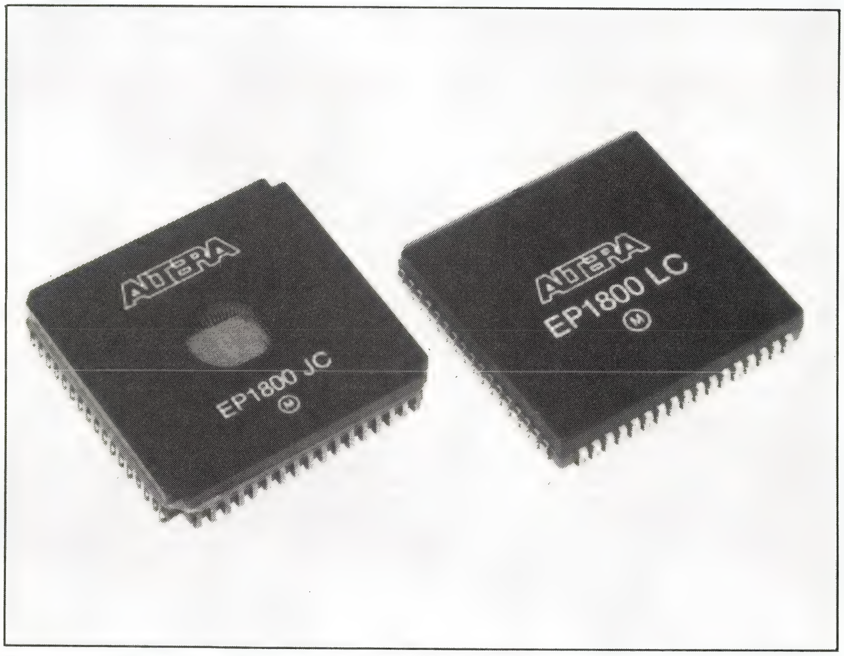


Fig B—A 68-pin J-lead carrier with a window (left) *allows you to erase the EP1800 under an ultraviolet lamp. A less-expensive carrier without a window* ***(right)*** *is available for production volumes.*

The diagram of the chip's architecture **(Fig A)** shows the interconnections of the device's circuitry. A global bus connects the input signals and global feedback lines to four macrocell quadrants. Each quadrant contains 12 macrocells, a local bus, and I/O-architecture control logic. The local bus connects signals from the macrocells to establish feedback lines within each quadrant. I/O architecture can create combinatorial logic or one of four types of flip-flops for output circuitry.

The EP1800's 68-pin J-lead carrier incorporates a window for ultraviolet light erasure **(Fig B).** The EPLD in this package costs $90. You can order one-time-programmable devices in plastic, windowless packages for $42 each. Both prices are for 100-piece quantities. Production volumes will be available in the third quarter of 1986.

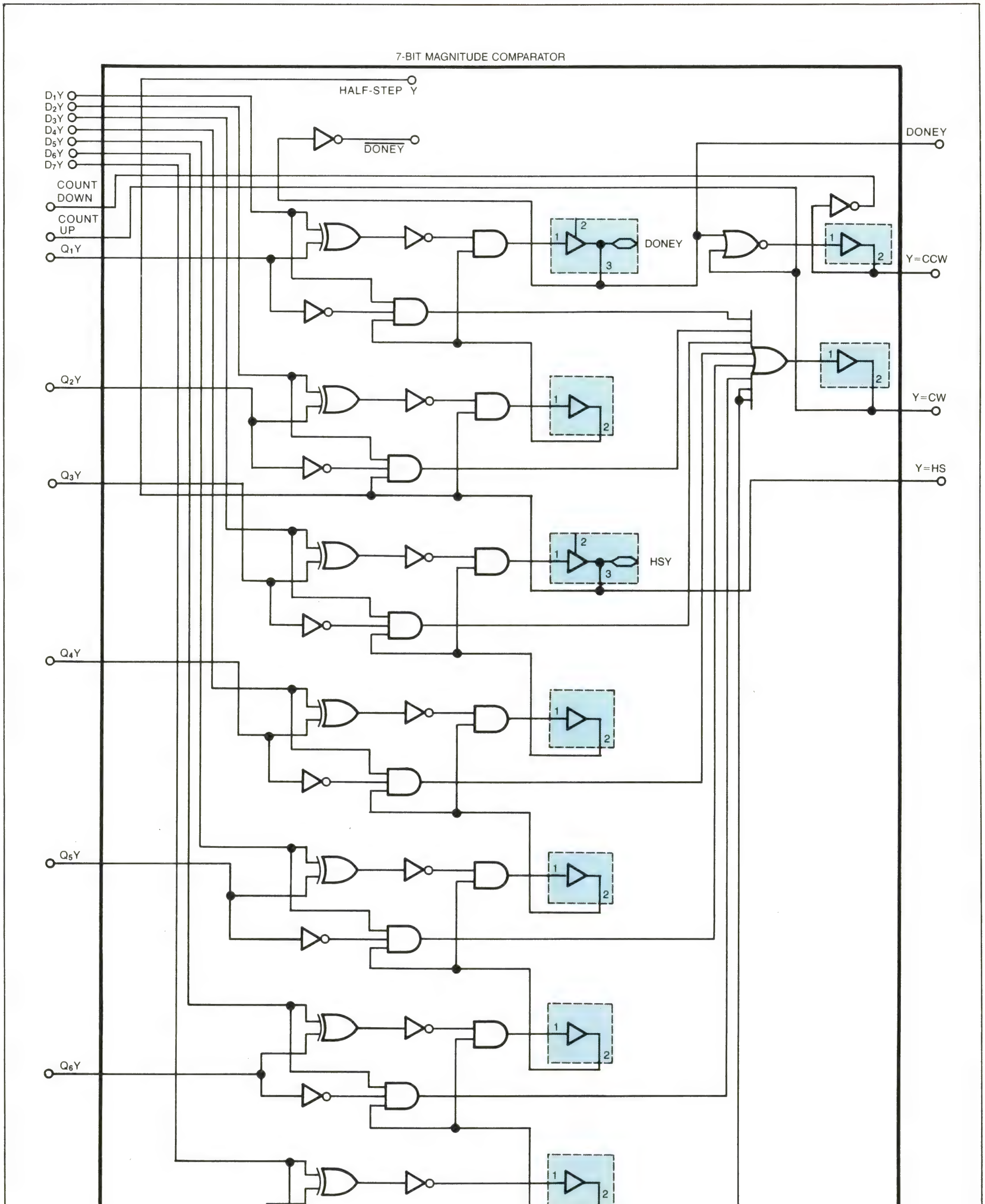


Fig 4—When actual and desired motor positions are unequal, *the magnitude comparators generate a CW or CCW signal to actuate the motor-control state machine. The half-step signal (HS) indicates that the five MSBs are equal; DONEY indicates that all bits are equal (ie, the motor is at the desired position).*

A design for a motor-positioning circuit illustrates how your logic design can exploit the logic and I/O circuits of an EPLD.

uses the combinatorial nature of the logic array. All of the logic between the multiplexer's clock inputs and the OR gate's output maps onto the logic array. Because both true and inverted versions of all inputs are available, Boolean logic guarantees that all combinatorial logic can be reduced to two levels of gates, allowing you to implement the logic in sums of products in the logic plane. The A+Plus support software does this logic reduction automatically. The multiplexer macrocell, unlike the macrocell in the divide-by-2 logic, serves only to select either the CLK or the CLK/2 signal for the CLKY output.

Counter uses feedback capability

The positioner's up/down counter keeps track of the actual position of the motors with respect to the desired position (**Fig 3** shows the counter for the Y axis). Like the multiplexer, the counter makes use of the EPLD's logic array. The counter begins at zero and counts up or down, depending on whether the count-up or count-down input is valid. Remember that the positioner's clock signal toggles only when the desired position is not the same as the actual position. Also, the data-valid input for Y-axis positioning, DVALIDY, enables the first flip-flop in the counter only when new data is valid at the Y-data input.

When DVALIDY goes high, the counter begins to count. The flip-flop at the top of the figure toggles and supplies both the LSB of the position and a signal that enables the rest of the counter's stages. The count-up and count-down inputs control these stages as well, designating which flip-flop in the counter will toggle next. As is the case with the multiplexer, the EPLD's logic array implements the combinatorial logic. Although the last stage contains the most inputs to an AND gate—eight—of any stage in this counter, the EPLD can implement more than 10 times that number of inputs to one AND term.

The reset signal in the counter presents an application of the dual-feedback capability of the EPLD. In the counter circuit, the reset signal connects to all of the flip-flops. The macrocell distributes the reset signal internally to all the flip-flops. In addition, within the macrocell, one of the counter's flip-flops feeds its Q output back into the logic array. Thus, a single macrocell is used for internal logic functions (counter-stage) and also for a dedicated input function (reset).

The positioner's magnitude comparators compare the desired motor position with the actual motor position (**Fig 4** shows the Y-axis comparator). When the desired position of the Y-axis motor (designated as inputs D_1Y through D_7Y), for example, is different from the actual position recorded in the up/down counter (Q_1Y through Q_7Y), the comparator generates signals that indicate the required motor movement: Y=CW for clockwise movement, Y=CCW for counterclockwise rotation, Y=HS for half-step rotation, and DONEY, of course, to indicate that the rotation is done and the actual and desired positions are the same.

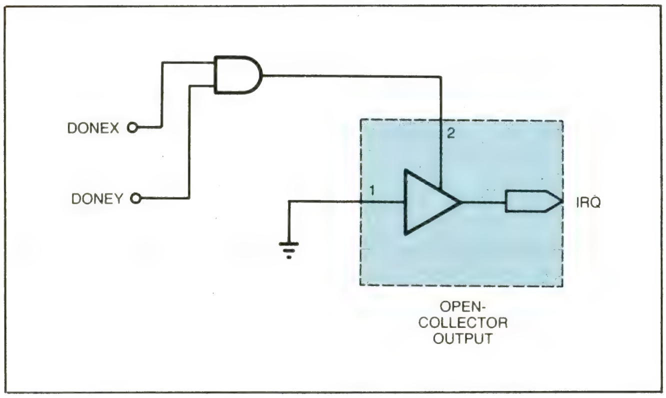
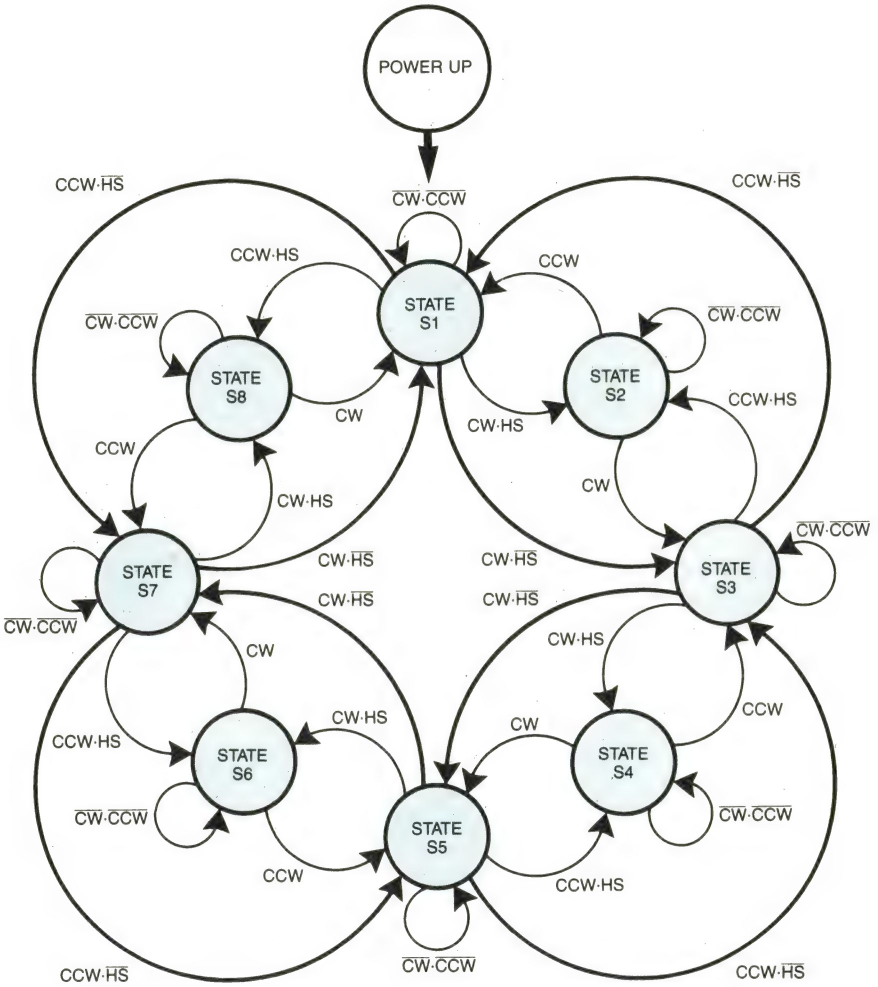


Fig 5—Any macrocell can implement an open-collector output, *allowing direct connection to a controller. The connection is typically a microprocessor interrupt-request line.*

The XOR gates in the comparator compare all of the bits from the desired and actual position inputs in order from the MSBs (D_7Y and Q_7Y) to the LSBs (D_1Y and Q_1Y). If, for example, all bits but the LSBs are equal, the XOR gates in each stage ripple an enable signal through to the last stage, enabling comparison of the LSBs. The difference between the actual and desired LSBs forces the positioner to generate one more signal. Once all bits are equal, the comparator generates the DONEY signal.

The circuit also compares the relative magnitude of the desired and actual positions. Thus, to move the motor toward higher desired values, the comparator circuit generates a CW signal. If the desired position has a lower value than the actual position, the comparator generates a CCW signal. As you can see from **Fig 4,** the logic that determines whether the comparator will generate a CW or a CCW signal begins with the connection of the desired MSB (D_7Y) and the complement of the actual MSB ($\overline{Q_7Y}$).

The comparator also generates a half-step signal (HS) that slows the rotation of the motors as they near their desired positions. The signal goes high when the five MSBs are the same. HS connects to the clock multiplexer and allows the half-step clock signal, in-



(a)

(b)

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STEPPER MOTOR CONTROLLER

PART: EP1800

INPUTS: CW    % CLOCKWISE ROTATION ENABLE %
        CCW   % COUNTER CLOCKWISE ROTATION ENABLE %
        HS    % ROTATE 3.75 DEGREE STEPS %
        CLKY  % CLOCK %

OUTPUTS: PH1Y PH2Y PH3Y PH4Y % MOTOR WINDINGS %

MACHINE: STEPPER_MOTOR_CONTROLLER

CLOCK: CLKY

STATES:  PH1Y  PH2Y  PH3Y  PH4Y

    PU    0     0     0     0
    S1    1     0     1     0
    S2    1     0     0     0
    S3    1     0     0     1
    S4    0     0     0     1
    S5    0     1     0     1
    S6    0     1     0     0
    S7    0     1     1     0
    S8    0     0     1     0

% FOLLOWING ARE STATE TRANSITIONS DEFINITIONS.
  IN ALL CASES AN ELSE HOLD IS IMPLICIT. %

PU:
  S1

S1:
  IF CW*/HS   THEN S3
  IF CW*HS    THEN S2
  IF CCW*/HS THEN S7
  IF CCW*HS  THEN S8

S2:
  IF CW   THEN S3
  IF CCW THEN S1

S3:
  IF CW*/HS   THEN S5
  IF CW*HS    THEN S4
  IF CCW*/HS THEN S1
  IF CCW*HS  THEN S2

S4:
  IF CW*/HS   THEN S5
  IF CW*HS    THEN S3

S5:
  IF CW*/HS   THEN S7
  IF CW*HS    THEN S6
  IF CCW*/HS THEN S3
  IF CCW*HS  THEN S4

S6:
  IF CW   THEN S7
  IF CCW THEN S5

S7:
  IF CW*/HS   THEN S1
  IF CW*HS    THEN S8
  IF CCW*/HS THEN S5
  IF CCW*HS  THEN S6

S8:
  IF CW   THEN S1
  IF CCW THEN S7

END$
```

Fig 6—A state diagram (a) describes the motor-control logic, *and EPLD-design software A+Plus automatically converts the state-diagram description* ***(b)*** *into appropriate programming to implement the logic in the EPLD. The logic converts the outputs of the comparator (Y=CW, Y=CCW, and Y=HS) into the control signals that drive the stepper motor.*

The clock input comes straight into a macrocell through the logic plane. You could also connect the signal with other signals via an AND gate.

```
                       P  P  P  P     P  P  P  P
           G  G  G  G  H  H  H  H  G  H  H  H  H  I  G  G  G
           N  N  N  N  1  2  3  4  N  4  3  2  1  R  N  N  N
           D  D  D  D  Y  Y  Y  Y  D  X  X  X  X  Q  D  D  D
         ---------------------------------------------------
        /  9  8  7  6  5  4  3  2  1 68 67 66 65 64 63 62 61  |
    GND | 10                                              60 | GND
    GND | 11                                              59 | GND
    GND | 12                                              58 | GND
    GND | 13                                              57 | GND
    D1Y | 14                                              56 | D1X
    D2Y | 15                                              55 | D2X
    D3Y | 16                                              54 | D3X
    D4Y | 17                                              53 | D4X
    Vcc | 18                    EP1800J                   52 | Vcc
    D5Y | 19                                              51 | D5X
    D6Y | 20                                              50 | D6X
    D7Y | 21                                              49 | D7X
DVALIDY / 22                                              48 / DVALIDX
    GND | 23                                              47 | GND
    GND | 24                                              46 | GND
  DONEY | 25                                              45 | DONEX
   RESET| 26                                              44 | CLOCK
        |_27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 _|
         ---------------------------------------------------
           Q  Q  Q  G  G  G  G  G  G  G  G  G  G  G  Q  Q  Q
           5  6  7  N  N  N  N  N  N  N  N  N  N  N  5  6  7
           Y  Y  Y  D  D  D  D  D  D  D  D  D  D  D  X  X  X
```

Fig 7—A pinout drawing of the completed design *is one output of the EPLD design software, A+Plus. Once you've completed your logic design, the software automatically assigns signals to pins and creates a hard-copy report on chip utilization.*

stead of the system clock signal, to pass through the multiplexer.

An AND gate generates an interrupt signal ($\overline{IRQ}$ in **Fig 5**) when the DONEX and DONEY signals from the positioner's two comparators are both high. The $\overline{IRQ}$ logic is unremarkable except that, because it connects directly to a microprocessor or controller, it's the only positioner signal that requires an open-collector output. Therefore, the macrocell that drives the $\overline{IRQ}$ signal off chip implements a grounded driver to provide the open-collector output.

State machine describes motor control

The final part of the positioner's circuitry translates the outputs of the comparator—CW, CCW, and HS—into the control signals that are required to drive the stepper motor. Control of the stepper motor is highly sequential: The motor has clearly defined operational states that the positioner must control in order to rotate the motor to the desired position. You can describe these sequential circuits as a state machine that accepts the comparator outputs and generates the four phase signals that control the stepper motor. The state-machine design can be an easier approach to designing sequential circuits than trying to create a logic diagram.

The positioner's state machine **(Fig 6a)** contains all of the states and transitions possible for the stepper motors (as defined in the motor's specifications). You can follow the operation of the motors by starting in any state and tracing the next state depending on the inputs from the comparator. For example, the positioner initializes to the first state (S1), and it can then go to one of five possible states, depending on the values of CW, CCW, and HS. Each state represents a specific combination of the outputs (PH_1Y through PH_4Y and PH_1X through PH_4X). Available personal-computer-based software, A+Plus, accepts this state-machine description **(Fig 6b)** and converts it into the appropriate programming code to implement the state machine on the EPLD.

Once you've entered the entire design (as logic schematics and a state machine), the design software creates an output that automatically assigns pins and produces a hard copy of the device's pinouts **(Fig 7)**. The software also produces a report that describes the utilization of the chip's resources. The positioner example uses 47 of the chip's 48 macrocells, a relatively good utilization of the chip. Also, your savings in board real estate are significant: A discrete-IC implementation of this stepper-motor controller would contain six MSI functions—the counters, comparators, and multiplexers—and dozens of SSI devices that the EPLD implementation does not require. **EDN**

Author's biography

Don Faria is an applications engineer with Altera Corp (Santa Clara, CA). He holds a BSEE degree from the University of Massachusetts and is currently pursuing an MSEE degree at the University of Santa Clara. Prior to joining Altera, he spent three years at Hewlett-Packard, where he was involved in semicustom-IC development. Don enjoys skiing, white-water rafting, and tracing the southern migration of elephant seals.

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CART/PPG World Champion Al Unser and his Pennzoil Z-7/Penske Racing March 85C. Photo by Doug Peacock.

L01

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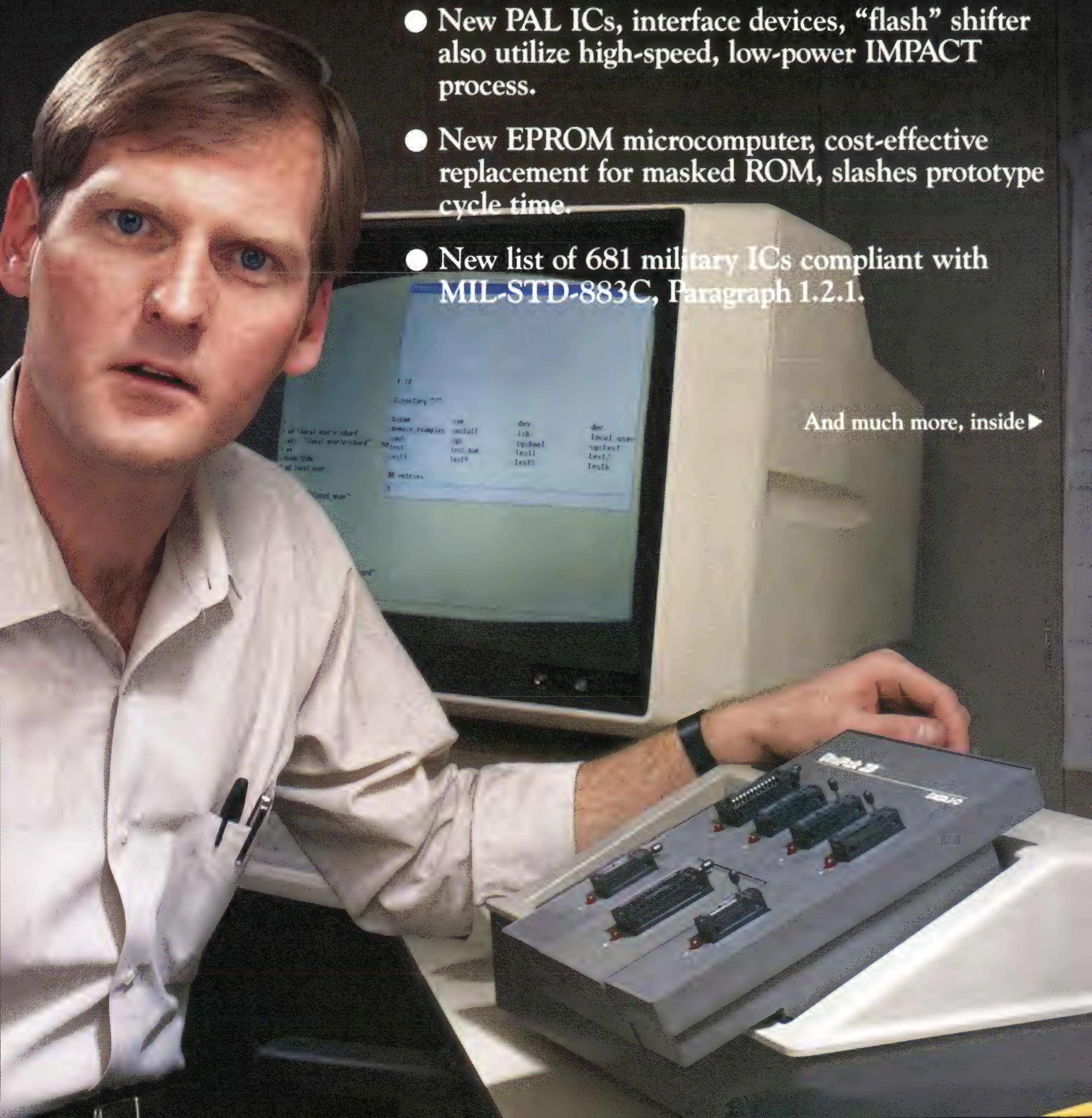

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You can also cut power without sacrificing speed, using TI's new TBP38L165-35 IMPACT PROM. It is pin-for-pin compatible with existing 2K × 8 PROMs and operates at the same 35-ns speed, but instead of 175 mA, it draws *only 100 mA*. TI's broad family of Series 3 IMPACT PROMs also includes 256-bit, 1K and 2K devices.

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IMPACT PROMs are designed by TI for exceptional reliability. Current densities, metal spacing, and contact sizes are all conservatively designed. Electrostatic-discharge tolerance up to 4,000 V is designed in. During programming, TI-developed titanium-tungsten fuse links insulate themselves with titanium-oxide caps. Electromigration is eliminated by copper-doped aluminum in the first-level interconnection. And you can program any of TI's new Series 3 PROMs on widely available commercial equipment, using TI's standard Series 3 programming algorithm.

Shift 32 positions in less than 29 nanoseconds.

Now TI's 2-μm IMPACT technology also brings you high-speed "flash-shift" operations — with the new 74AS8838 32-bit barrel shifter. Shifting as many as 32 positions in a single 29-ns instruction cycle, it can dramatically increase throughput in such applications as graphics systems, wide-word CPUs, and array processors. At an energy cost of less than 1.5 W, you get higher speed with lower power, in a single 84-pin ceramic pin-grid-array package.

You can program the 74AS8838 for logical, circular, or arithmetic shifts. Its two 3-state, 16-bit outputs give it the versatility to be configured as a 32-bit-in, 32-bit-out barrel shifter, as a 16-bit funnel shifter, or as a 16-bit shifting transceiver. And it can drive buses directly with 24-mA low-level output — with no additional circuitry.

The 74AS8838 barrel shifter, first device in TI's 74AS88XX 32-bit processor chip set, is available today through your local authorized Texas Instruments distributor.

IMPACT technology doubles speed of new PAL ICs.

Four new exclusive-OR programmable-array logic (PAL®) ICs from TI feature the highest speed available today. Their 20-ns propagation delay at 180 mA makes them twice as fast as any comparable devices.

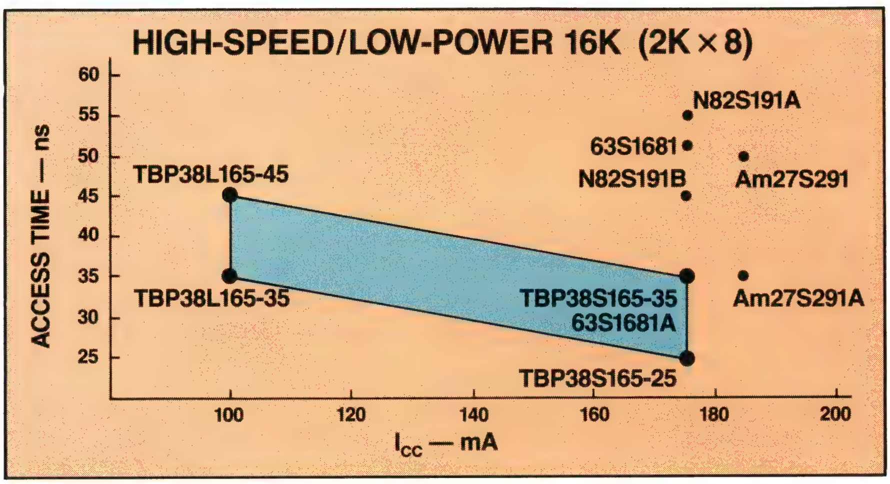
These devices — TIBPAL20L10-20, TIBPAL20X4-20, TIBPAL20X8-20, and TIBPAL20X10-20 — are designed primarily for counter-intensive applications. The exclusive-OR feature suits them ideally to digital voice applications and video-screen information correction. They can also be useful in memory addressing and mapping.

Programmable logic sequencer is 250% faster because of IMPACT processing.

Still another new product in TI's growing line of high-speed programmable logic devices is the TIB82S105B. At 50 MHz, it is 2½ times as fast as functionally equivalent 16 × 48 × 4 field-programmable logic sequencers — at the same 180-mA power. Unlike them, however, it maintains that speed even when using many product terms.

Because of its improved clocking scheme, the IMPACT TIB82S105B is not a direct replacement for the TI or Signetics N82S105A. But it is ideal for those new high-speed state machines designed to control peripheral I/O, dynamic memory systems, and video blanking systems.

For more detailed information about any of TI's growing line of high-speed, low-power IMPACT products, just check the appropriate box on the attached reply card and return it to TI.



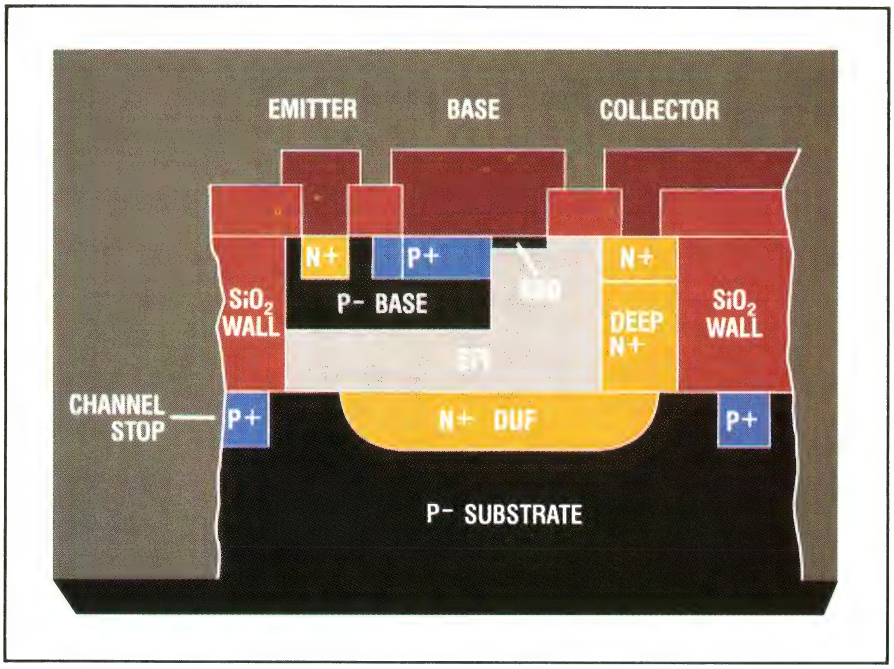
Bracketing the speed/power spectrum, TI's IMPACT PROMs cut power requirements from 180 to 100 mA for "standard" 35- to 45-ns access time. Or at 180 mA, they can give you 25-ns speed.

High-density IMPACT circuits speed logic, memory access.

TI's unique Implanted Advanced Composed Technology (IMPACT) capitalizes on the advantages of ion implantation, oxide isolation, and composed-masking techniques to increase the speed and density of bipolar ICs.

This innovative technology dramatically reduces the size and the sidewall capacitance of circuit elements (*see diagram*). As a result, speed/power ratios are significantly improved: In PROMs that cut power consumption by 43%, or more than double the speed (*see story opposite*). In PAL ICs that reduce propagation delay by as much as 40% — to only 15 ns at 180 mA.

With the high speed and low power that TI's IMPACT process makes feasible, its potential for large-scale integration will reduce package counts in many high-complexity circuits.



A major reduction in capacitance results from the 2-μm feature size which TI's IMPACT processing makes possible. Silicon dioxide is the isolation material. Switching speed is further enhanced by utilizing this silicon dioxide for emitter and base sidewalls.

Composed masking yields high density

In composed masking, critical components are defined on the chip with a minimum number of masks. Thus they can be more tightly defined and more densely spaced than by conventional masking.

The IMPACT process also makes it possible to insulate critical base and emitter components with oxide walls. This insulation reduces sidewall capacitance, which, at the 2-μm dimensions of IMPACT features, can represent as much as half the overall capacitance. Small size and oxide walling together contribute significantly to the increase in switching speed.

DRAM technology spurs IMPACT growth

The IMPACT process is not a direct descendant of DRAM technology. Nevertheless, TI's commitment to DRAM production has provided IMPACT technology with vital processes.

It was the DRAM effort, for example, that drove photolithography to its present advanced state and contributed key dry-etching processes. Ion implanters designed to produce CMOS DRAM ICs enhance the quality — and the economy — of TI's bipolar IMPACT ICs. And this vital "cross-fertilization" from VLSI memory is one reason Texas Instruments — almost alone among U.S. semiconductor manufacturers — is committed to the development and manufacture of DRAM devices.

◀ **More chips per slice** help cut costs. The 150-mm wafers now used on TI's advanced MOS 256K DRAM wafer-fabrication line have 125% more area than the 100-mm slices formerly used.

your competitive edge.

6

Keeping you competitive: ASICs and TI.

If you're looking for increased system-level integration and performance, shorter design-cycle time, and reduced VLSI development costs, take a hard look at application-specific integrated circuits (ASICs). And a long look at TI.

Broad choice lets you pick the right implementation

Texas Instruments supports an extensive library of 3-μm CMOS standard cells — more than 200 of the standard SN54/74 TTL functions you have designed with for years — including MSI, analog, and procedural LSI functions like RAM, ROM, PLA, and ALU. In addition, high-drive cells (up to 48 mA) are true TTL replacements.

From TI's new family of advanced standard cells you'll be able to choose among more than 280 functions and achieve increased system integration and performance.

Or for the performance you need, and quick turnaround to get your product to market fast, there's TI's DLM TAC-H and TAC-VH silicon-gate CMOS gate-array family. These devices, fully alternate-sourced, offer complexities from 440 to 8,000 gates.

Extensive design support

Whatever level of help you need, you get it from TI. In your design cycle as well as in meeting your prototype and production requirements *on time.* TI's proven expertise and worldwide manufacturing facilities are your assurance of dedicated support and products in the volume you require. And you have a wide range of package options: DIPs, SOs, PLCCs, pin-grid arrays — from 8 to 179 pins.

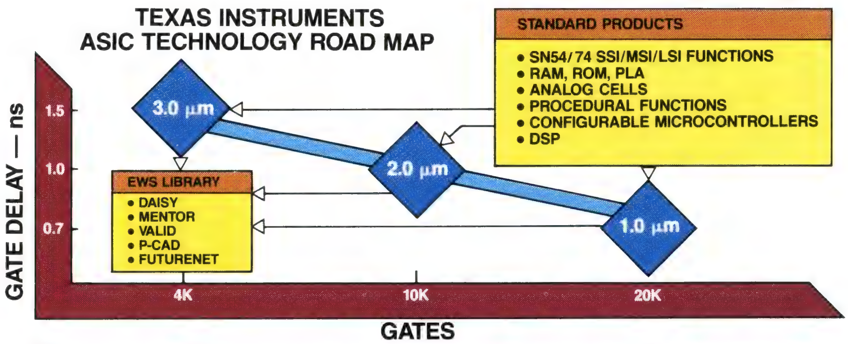
Design your own way

You can reduce your costs and speed your ASIC design with TI because you don't need special proprietary software or design tools. And you can do it at a TI regional design center or at your own work station. Because TI's cell libraries are supported by most work stations, including Daisy LOGICIAN®, MEGALOGICIAN®, and GATEMASTER®; Mentor IDEA 1000®; Valid SCALDsystem®; and P-CAD® and FutureNet® in IBM PC® environments.

TI's worldwide network of 13 training and design centers, staffed with experienced ASIC design engineers, can provide access to work stations, as well as mainframe capability. And you can learn ASIC design in one of TI's unique hands-on workshops. Using TI's semicustom libraries with a real-world standard-cell example, you'll learn every phase of design from schematic capture through test-pattern generation and simulation.

Select TI distributors can also give you local access to TI's leading-edge ASIC options, with dedicated facilities, tools, and trained engineers.

To find out more about what TI ASICs can mean to you, check the appropriate box on the return card.



Advancing technology in ASICs need not demand new rules and tools. Your investment in hardware and training is protected when you move up with Texas Instruments to faster, more complex ASIC functions.

7

New series of input-latched and registered PAL ICs lowers parts counts.

Eight new 30 MHz PAL devices from TI are the first input-latched (TIBPALT19XX) and input-registered (TIBPALR19XX) PAL ICs in the marketplace. Functionally similar to TI's TIBPAL20XX series, they include either 11 D-type transparent latches or 11 D-type input registers on chip. This added circuitry allows you to synchronize inputs without external registers or latches. These devices can reduce your parts counts and simplify your design task in a wide range of applications such as random logic, bus-interface logic, and input synchronization to custom controllers.

8

And now, a new, easy-to-use EPROM microcomputer.

TI's new TMS7742 EPROM microcomputer can cut to zero your lead time for development, prototyping, field tests, and product qualification. And it bridges the gap to ROM-based volume production. For low-volume applications, it can be a cost-effective alternative to mask-programmed ROM. Its 4K bytes of on-chip EPROM are identical to TI's TMS2732A — transferred into the chip area vacated by masked ROM. So if you can program the TMS2732A you can program the TMS7742. This new microcomputer provides EPROM capability for the TMS7020, the TMS7040, and the new TMS7042 ROM microcomputer.

Also new to TI's TMS7000 family is the ROM-less TMS7002 microprocessor. Both the TMS7002 and the TMS7042 feature 256 bytes of RAM, a serial port for USART and serial I/O functions, 32 I/O lines, and three timers. And with their 60% performance increase over earlier TMS7000 ICs, they can improve system performance in such applications as disk and tape drives, printers, and industrial and motor controls.

8 new ways TI can help sharpen

1

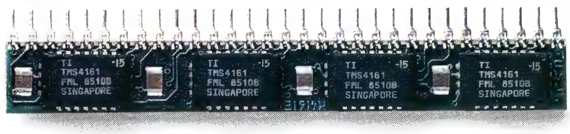
A new alternative for memory-systems lesign: TI SIP DRAM nodules.

Memory-intensive packaging for the fu-ure is available today — in TI's highly eliable modules in single-in-line pack-ges (SIPs). With them you can have he many advantages of surface-mount echnology (SMT) — while using hrough-hole-mounted or ocketable packages. Thus vithout changing your man-ıfacturing technology, you an increase memory density y a factor of up to 3.5 over lual-in-line packages (DIPs). And you an simplify board layout while facil-tating replacement and future upgrades.

Each SIP module uses DRAM chips n plastic leaded chip carriers (PLCCs), surface-mounted along with decoupling capacitors on an epoxy substrate. Since all connection points are on one edge of the substrate, the module "stands on end" to make the most of your board area.

TI's full line of SIP memory modules — from 64K × 4 to 256K × 9 and 1M × 1 — includes standard DRAMs and Multiport Video RAMs in various organizations. And all are available through your authorized TI distributor.

For more information, just check the appropriate box on the reply card.



Memory can be 3.5 times denser using fully-qualified, production-proven RAMs configured in SIP modules. TI SIPs combine the density of surface-mount technology with economies of through-hole insertion.

2

Interface performance enhanced by TI.

Also new from Texas Instruments is an mproved direct replacement for the JCN5812 vacuum fluorescent display lriver. TI's TL5812 is 11% faster and draws 60% less current. With an output voltage swing of 70 V and an output source-current capability of 40 mA.

Only TI's patented BIDFET technology — combining bipolar, double-diffused MOS (DMOS) and N-channel and P-channel CMOS transistors on the same chip — makes these improvements possible. And at a competitive price.

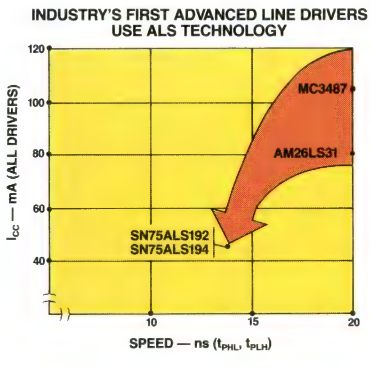
3

Fast line drivers and bus transceivers from TI.

n the new SN75ALS192/194 quadru-ple EIA Standard RS-422-A differential ine drivers, TI's exclusive ALS 1.5 pro-ess technology (oxide-isolated Ad-vanced Low-power Schottky) yields the pest speed/power ratio in the industry: At approximately half the power con-umption, these devices are 30% faster han the competition.

A new family of differential bus ransceivers, SN75176B, 177B, 178B, and 179B, are faster than earlier ver-ions. Designed for bidirectional com-munication on multipoint transmission ines in noisy environments, they meet EIA Standards RS-422-A and RS-485. Typical propagation time is only 22 ns.

Want to know more about these new interface products from TI? Just check the appropriate box on the reply card.



Advanced TI line drivers are 30% faster, typically draw only half the power of the devices they are designed to replace.

4

Fast, economical new 8-bit SAR A/D converters.

Now Texas Instruments offers 8-bit SAR (serial-approximation resolution) A/D converters that are as economical as any you can use. And because they use LinCMOS™ polysilicon-gate-process technology, they are unsurpassed in speed. TI's TLC549 analog-to-digital converter performs 40,000 conversion cycles per second (cps), while the new TLC548 pushes speed to an unprecedented 45,500 cps. At any supply voltage between 3 and 6 V. And typical power consumption is only 6 mW.

Performance of the serial-approximation algorithm is not only fast. It's accurate: Conversions are performed with the guaranteed low error rate of ±0.5 LSB (least significant bit) across the temperature range from −55° to 125°C.

5

681 military TI devices comply with 1.2.1.

Now designers of military electronics have the broadest choice ever of devices that comply with the requirements of MIL-STD-883C, Paragraph 1.2.1. The vast majority of TI's military ICs — 681 different devices — now qualify:

Product Type	Number
ALS/AS	83
TTL	131
LS/S	238
HCMOS	80
PAL ICs	16
Linear	113
Memory/LSI	19
MOS DSP	1
TOTAL:	681

For more detailed information on specific TI military devices, just check the appropriate box on the reply card.

Texas Instruments quality recognized in Tokyo and Detroit.

Outstanding Texas Instruments quality-assurance programs were lauded during 1985 both at home and abroad. In June, Ford Motor Company granted TI linear products the coveted Q1 Award. And in November, TI's wholly owned Japanese semiconductor operation received the prestigious Deming Prize. Both awards recognize exceptional levels of quality and reliability, achieved through aggressive defect-prevention programs.

First Ford Q1 Award to a semiconductor supplier

Ford Motor Company's Q1 Award to Texas Instruments Linear is the first ever to a major U.S. semiconductor manufacturer.

Qualification is based on a demonstrated defect-prevention program, along with Ford's review of warranty returns, specifically keying part numbers to failures. Thus it recognizes both initial product quality and continuing reliability.

Both quality and reliability are attributes that TI Linear has pursued aggressively through its "monitor program," begun in 1979. The goal of the program has been to achieve levels of quality and reliability equal to or better than the best worldwide competition. And the Ford Q1 Award is one visible token of its success.

First U.S. winner of Japan's Deming Prize

At ceremonies on November 11 in Tokyo, the Japanese Union of Scientists and Engineers awarded the prestigious Deming Prize for total quality control to TI's bipolar semiconductor operation in Japan.

The prize, never before won by a wholly U.S.-owned company, recognizes outstanding quality-control achievement in all aspects of business — including marketing, engineering, manufacturing, and support. It is named for W. Edwards Deming, the American statistician whose work in defining and measuring quality control in Japan after World War II became the basis for the legendary Japanese commitment to quality. In 35 years, the Deming Prize has been awarded to only 48 individuals and 111 institutions. Texas Instruments Japan, Ltd. was one of only eight companies so honored in 1985.

As is the case with the Ford Q1 Award, sensitivity to customers' requirements is a key factor in selecting winners of the Deming Prize. TI's successful commitment to quality and reliability in support of all our customers' needs has been demonstrated twice again. And TI is justifiably proud of this achievement.

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More news upcoming from TI in the next issue:

- **A new CMOS version** of TI's trend-setting TMS320 Digital Signal Processor.
- **More new additions** to TI's growing family of IMPACT PAL ICs.
- **New CMOS standard cells** and gate arrays that augment TI's leadership in Application-specific Integrated Circuits (ASICs).
- **And more . . .**

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Dynamic signal analyzers simplify measurement of linear control systems

Advanced dynamic signal analyzers (DSAs) give designers a wide choice of techniques for measuring a system's open-loop frequency response. This article, part 2 of a 3-part series, considers the effect of DSAs on the graphical measurement techniques of linear control-system theory. Part 1 of the series presented an overview of classical linear control theory. Part 3 will explore the expanded role of DSAs in the control-system design process.

Steve Asbjornsen and Owen Brown,
Hewlett-Packard Co

You can use a variety of graphical techniques to analyze a negative-feedback, closed-loop control system (**Ref 1**). Bode plots, Nichols diagrams, and Nyquist diagrams are three distinct tools that allow you to determine a system's amplitude and phase characteristics (and, therefore, its stability) as functions of frequency. Typical test instruments make use of these tools, and a dynamic signal analyzer (DSA) is no exception—it allows you to view and plot frequency-response data in all three formats.

The internal analysis functions of modern DSAs, however, alter the relative usefulness of these three graphical techniques. Understanding these DSA functions gives you an idea of how a DSA's computational power can expand your test options.

Waveform math and Nyquist diagrams

A DSA's waveform-math capability, for example, limits the Nyquist diagram's usefulness to providing a complete check of a system's stability and a 1-trace representation of its frequency response. The waveform-math utility is a built-in calculator that allows you to add, subtract, multiply, divide, or use any of the other operators shown in **Table 1** to manipulate frequency responses, recorded waveforms, and complex constants.

The Nyquist diagram lets you easily determine the stability of all types of systems, including absolutely and conditionally stable systems. You can also directly calculate the closed-loop frequency response of a unity-feedback control system. However, the diagram doesn't facilitate calculation of composite frequency responses, and its linear scales can't accommodate both adequate gain ranges and acceptable resolution around the unity-gain point. Reading phase margin is more difficult with the Nyquist diagram than with other diagrams, and reading the open-loop bandwidth is

A DSA's built-in calculator uses waveform math to perform arithmetic operations and to manipulate frequency responses, waveforms, and complex constants.

TABLE 1—WAVEFORM-MATH FUNCTIONS IN A DSA

ADD	SQUARE ROOT	MULTIPLY BY $j\omega$	T/(1−T)
SUBTRACT	RECIPROCAL	FFT	REAL PART
MULTIPLY	NEGATE	INVERSE FFT	COMPLEX CONJUGATE
DIVIDE	DIFFERENTIATE		LOG DATA

impossible unless the frequency at which the gain becomes unity is recorded on the plot. Finally, you can't use the Nyquist diagram to estimate the transfer function of a system from its measured frequency response, or vice versa.

A DSA's waveform-math utility, however, lets you calculate a system's closed-loop response precisely, in any format, using the equation

$$C(j\omega)/R(j\omega)=G(j\omega)/\{1+G(j\omega)\}.$$

Using waveform math, you can calculate closed-loop frequency response independently of the display format. Linear scales are not a problem when you're using a DSA, because the DSA's display can easily rescale the data. The DSA's marker readouts make the measurement of gain margin, phase margin, and open-loop bandwidth much easier.

Bode plots

DSAs also alter the usefulness of the Bode plot, which designers have traditionally favored because they could use it to estimate composite frequency responses quickly. The Bode plot's logarithmic units offer a large dynamic range of gains, and the plot makes it easy to measure gain margin, phase margin, and open-loop bandwidth. Finally, unlike the Nyquist diagram, the Bode diagram lets you estimate a transfer function from a frequency response and vice-versa.

The Bode plot's major drawbacks are that you have to plot traces for both gain and phase, and that you can't estimate the closed-loop frequency response from the open-loop frequency response. A DSA's waveform-math utility makes it easy to calculate the closed-loop frequency response, however. Further, the DSA's frequency-response-synthesis and curve-fitting functions automate the transition between frequency responses and transfer functions.

The Bode plot is still useful in that it helps you intuitively understand the frequency-response/transfer-function transition. The Bode plot also helps you estimate composite waveforms, and its logarithmic gain units provide both range and resolution.

Although the Bode plot and Nyquist diagram are still useful to designers who perform system analysis on DSAs, Nichols diagrams are not. The Nichols diagram's only advantage over the other diagrams is that it lets you calculate closed-loop frequency responses. Because the waveform-math capability of DSAs solves this problem, it renders the Nichols diagram obsolete.

The root-locus plot

The newest method of making control-system measurements is root-locus analysis, which was developed in the late 1940s and early 1950s by Walter R Evans. All previous methods of analysis had used open-loop frequency response solely to determine whether closed-loop poles with positive real parts existed. These methods yielded no additional information concerning the actual value of s for the poles. The root-locus technique, however, lets you examine the actual values of s for the closed-loop poles graphically, based on the known values of s for the open-loop poles and zeros.

The root-locus diagram could not have been conceived without the development (in the late 1940s) of the s-plane. The s-plane is a 2-dimensional plane that represents all possible values of the Laplace variable s. The plane's ordinate is the imaginary part (ω of $s=\sigma+j\omega$), and its abscissa is the real part (σ of $s=\sigma+j\omega$), of s **(Fig 1).**

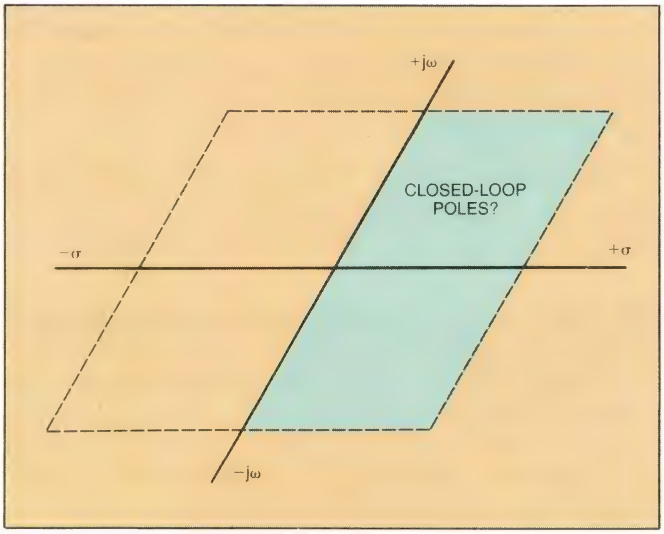

***Fig 1—The s-plane represents all possible values of s** in two dimensions. This plot allows you to locate the poles and zeros of a closed-loop transfer function and thereby determine the stability of the system characterized by the transfer function.*

Each value of s, therefore, has a unique position in the s-plane. If you can determine the poles and zeros of a ratio of polynomials (such as the open- and closed-loop transfer functions of a control system) in s, you can plot the location of these poles and zeros in the s-plane. Any closed-loop pole that exists in the right half of the s-plane represents poles with positive real parts and therefore indicates an unstable system.

In measuring the open-loop frequency response of a system, you're collecting the same data you would if you were evaluating GH(s) for values of s that lie on the positive ordinate of the s-plane ($s=0+j\omega$ for $\omega=0$ to +infinity). From the open-loop information, Nyquist—without using the idea of the s-plane—made the conceptual leap that allowed him to determine whether there were any values of s with positive real parts that solved the equation $GH(s)=-1$. His observation was not an obvious one, to say the least.

Consider a control loop that has been opened so that the open-loop frequency response ($GH(j\omega)$) is measurable. If you alter just the gain of the loop, you won't affect the value of the open-loop poles and zeros. As a result, the open-loop transfer function can be expressed as $GH(s)=KGH(s)$, where K represents a proportional gain constant that's independent of s.

Although varying K has no effect on the position of the open-loop poles and zeros, it can have a tremendous effect on the closed-loop poles. This effect becomes apparent if you substitute KGH(s) in the denominator of the closed-loop transfer function $G(s)/\{1+GH(s)\}$ and solve the equation for the poles. The resulting expression is $1+KGH(s)=0$.

The closed-loop poles, therefore, are values of s that are solutions to the equation $GH(s)=-1/K$. To locate the closed-loop poles, you must, whenever K changes, find new values of s that satisfy the equation $GH(s)=-1/K$. It was this relationship—between the stationary poles and zeros of the open-loop transfer function, and the closed-loop poles that vary with pure gain—that provided the basis for Evans's root-locus technique.

Using the root locus

The root-locus technique plots the open-loop poles and zeros in the s-plane. You can obtain the open-loop pole and zero locations from a mathematical derivation of the open-loop transfer function or by using Bode's techniques to extract the transfer function from a measured frequency response. If you plot the open-loop poles and zeros on the s-plane **(Figs 2a and 2b)**, you can

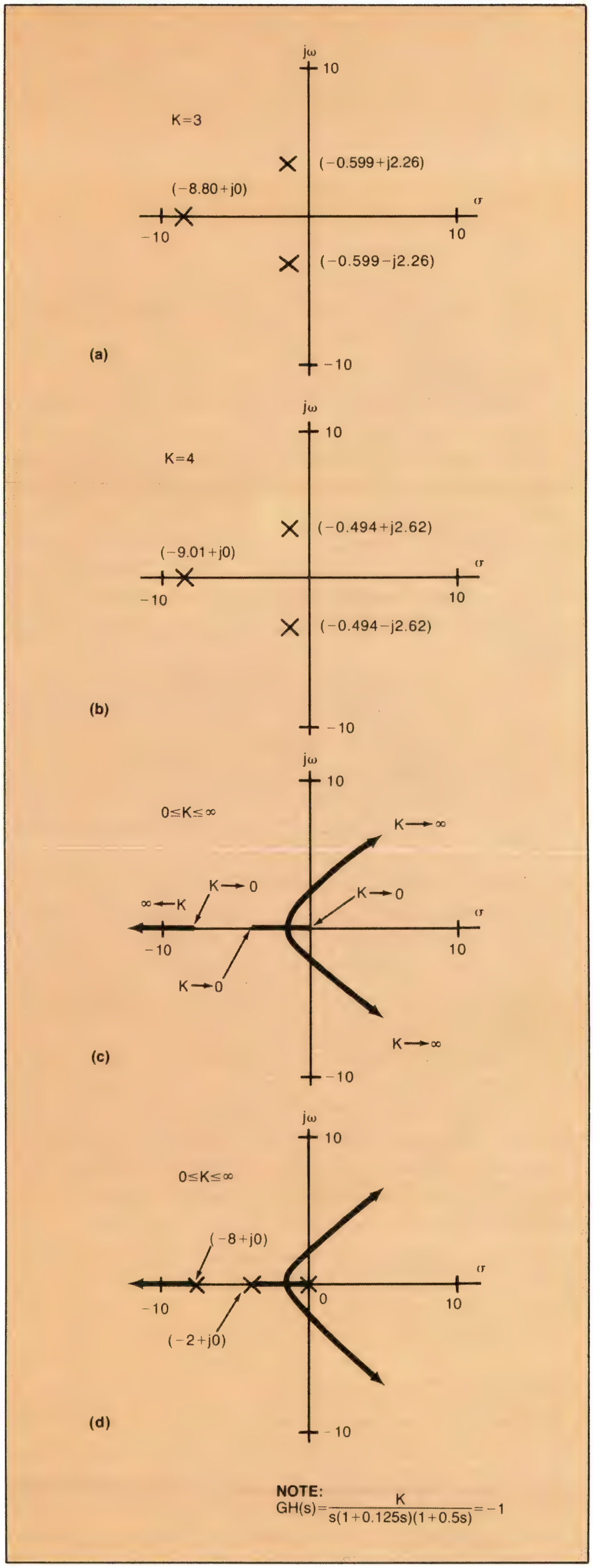

Fig 2—A powerful graphical technique, the root-locus plot, *allows you to determine the location of poles in a closed-loop system without actually measuring the closed-loop response. This method depicts the migration of poles as the system's frequency-independent gain (K) varies.*

use Evans's graphical techniques to draw a trace that represents the migration of the closed-loop poles (or root loci) as the frequency-independent gain varies **(Figs 2c** and **2d).**

The advantage of this technique lies in its ability to give the actual location of closed-loop poles without actually measuring the closed-loop response. However, using graphical techniques to determine the root loci doesn't give you the actual value of the frequency-independent gain (K) at any particular point in a locus. You must return to the equations and calculate the closed-loop pole locations for several values of K until you discover the value of K that corresponds to some point on a locus.

The root-locus technique also requires that you know the number and location of the open-loop poles and zeros before you can estimate the position of the closed-loop poles. The technique is, therefore, less flexible than the Nyquist or Bode diagrams, which let you predict stability, measure performance, and obtain design information, but allow you to measure only the open-loop frequency response. The root-locus method, however, provides you with more information during the initial design process, and it's better suited to the design of the complex compensation networks typically associated with complex systems. Also, because you know the position of the closed-loop poles, you can derive the time-domain response for a given value of gain (K).

Almost all linear control-system analysis, and much of the subsequent designs, depends on obtaining an accurate estimate of a system's open-loop characteristics, either in the form of a frequency response $GH(j\omega)$ or the closed-loop transfer function $GH(s)$. No matter how these open-loop characteristics are expressed, designers must always perform the actual physical frequency-response measurements, whether to help construct system models or to verify them.

Measurement techniques

In the past, engineers had to choose between two types of analyzers for making low-frequency control-system measurements. They could choose either the classic frequency-response analyzers (FRA), which provide swept-sine measurements, or fast-Fourier-transform analyzers (FFTA), which can measure a whole spectrum in one measurement.

The two analyzers have different advantages and disadvantages. For example, although the FFTA has the potential for faster measurement times, it entails complex set-up procedures. And although the FRA is familiar to engineers, who understand its swept-sine method of measurement, its measurement times are slow. However, because DSAs offer both measurement techniques, designers no longer have to accept the tradeoffs that accompany choosing an FFTA or an FRA.

Frequency-response analyzers

FRAs operate in much the same way as do heterodyne network analyzers, and they're limited to taking measurements at low frequencies. They generally possess two channels, each of which uses a discrete Fourier transform to emulate a single bandpass filter. The Fourier integration time controls the filter's bandwidth to values in the low microhertz range, and an integrated sine-wave source **(Fig 3)** synchronizes the filter's center frequency.

A stimulus signal from the FRA drives the device under test. The analyzer's two channels connect to the input and output of the device, and the signal each channel receives undergoes comparison with the stimulus signal as a function of the discrete Fourier transform. The result is a complex value containing the magnitude and phase (with reference to the stimulus signal) of the measured signal.

The FRA then compares the two channels' results, deriving the gain and phase-shift relationships between the two channels' signals. This process occurs several

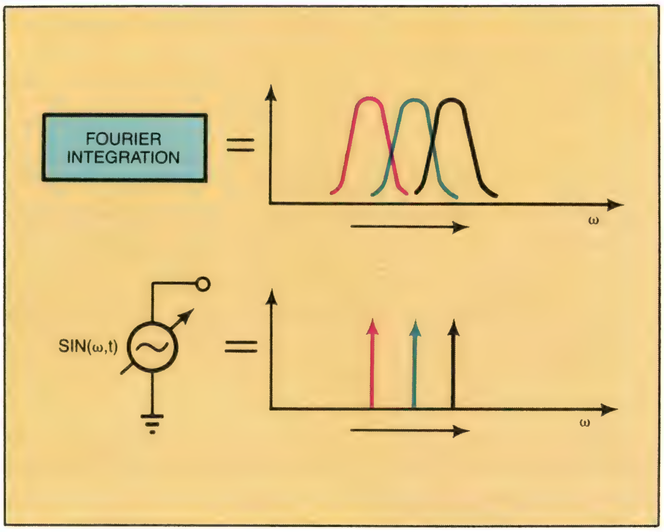

***Fig 3—The integration time of a Fourier transform** controls filter bandwidth, and a sine-wave signal source sets the filter's center frequency. Each discrete Fourier transform emulates a single bandpass filter.*

A root-locus diagram allows you to examine the values of s for a system's closed-loop poles, based on the known values of s for the open-loop poles and zeros.

times between the start and stop frequencies being analyzed, thereby producing a series of discrete gain and phase values. When you connect these points graphically, you obtain the gain and phase curves of the frequency response. Note that this measurement process has two implementations, and the difference between them can be important to the designer who uses computer-aided analysis.

The primary distinction between the two implementations lies in the sources. An FRA whose source sweeps continuously can integrate the signal while the source is actually sweeping. Each integration period, therefore, covers a small part of the total measurement span. The result of that integration is then available at the end of each integration period.

This continuous-sweep technique creates a potential ambiguity between the phase and magnitude values for the displayed frequency, and the exact frequency at which they occurred. The ambiguity becomes especially serious when the integration period covers large frequency spans. Because the integration period is typically fixed, you can generally minimize this problem by reducing the sweep speed—and therefore the frequency span covered—during integration. The ambiguity won't interfere with graphical analysis, but it can create difficulties in computer analysis.

Sweep-and-dwell sources

The alternative to the continuous-sweep implementation is a sweep-and-dwell sine-wave source. In this type of analyzer, the sine-wave source dwells at a discrete frequency during the integration process and then performs a phase-continuous sweep to the next analysis frequency.

Because a sweep-and-dwell analysis occurs at a discrete frequency, the phase and gain analyses apply only for the frequency point at which the measurement was made; therefore, no ambiguity exists. DSAs incorporate this sweep-and-dwell form of swept-sine analysis, which optimizes the accuracy of their integrated computer-aided-analysis functions.

One possible drawback to the sweep-and-dwell technique is that the analyzer might miss valuable information between measurement points. However, by simply decreasing the sweep rate of these analyzers, you increase the number of measurement points between the start and stop frequencies and provide better resolution.

Newer analyzers offer an autoresolution function that monitors the gain and phase shift between measurement points and automatically adjusts the resolution (ie, sweep rate) during the sweep, thereby preventing the loss of valuable data. This function can also minimize total sweep time by increasing the sweep rate in portions of the frequency response that are relatively flat in both gain and phase.

FFT analyzers

Fast-Fourier-transform analyzers (FFTAs) are similar to FRAs in that they use a type of Fourier transform to achieve narrow analysis bandwidths. Their method of signal generation and use of two channels to compare a device's input and output are also the same as those of the FRAs. However, instead of emulating a single bandpass filter and tracking it over the spectrum of interest, FFTAs emulate hundreds of bandpass filters **(Fig 4)** and provide complete coverage of an entire spectrum in one integration period. FFTAs can usually perform measurements much more quickly than can FRAs.

In addition to the increased number of analysis bands, the FFT process can also use a wide range of stimulus signals. They typically use stimulus signals (such as random noise) that provide energy over the entire analysis span, thus taking full advantage of the analysis power.

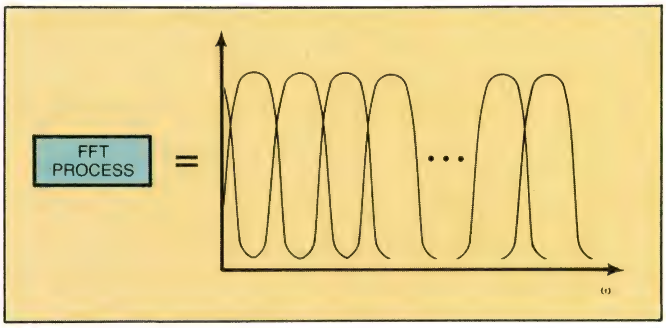

Fig 4—FFT analyzers emulate hundreds of bandpass filters. *One integration period, therefore, provides complete coverage of an entire spectrum. The FFTA can use a wide variety of stimulus signals, including random noise.*

FFTAs and FRAs use different methods to reduce measurement noise. If you don't know what the differences in the methods are and how they affect the measurement process, you can very easily misuse an FFT analyzer. Designers lacking this information have sometimes concluded—mistakenly—that FFT analyzers can't make control-system measurements.

Although the term "swept-sine analysis" describes the FRA's stimulus signal, it doesn't describe the

The sweep-and-dwell sine-wave stimulus is better than any other type of stimulus for measuring noisy systems.

FRA's unique analysis process comprehensively (heterodyne analyzers also use a swept-sine stimulus). The term "swept Fourier analysis" (SFA) describes the FRA's measurement process more specifically. The differences between FFT and SFA measurement processes lie mainly in their stimulus signal, single- versus multiple-band analysis, and noise-reduction techniques.

Stimulus signals in SFAs and FFTs

The SFA measurement process uses a swept-sine-wave stimulus, and the FFT process uses stimuli that produce energy at all the analysis frequencies within a single integration period. When you're measuring extremely noisy systems, the type of stimulus itself can have a profound effect upon the measurement.

The sweep-and-dwell sine-wave stimulus is better than any other type of stimulus for measuring noisy systems, because the power of the stimulus is concentrated at one discrete frequency. This concentrated-power approach automatically provides the best possible signal-to-noise ratio without any signal processing. A random-noise stimulus, on the other hand, must distribute its energy over a wider bandwidth, providing less power at any one discrete frequency than would a dwelling sine wave (ie, its power spectral density is much lower than a sinusoid's) **(Fig 5).**

A random-noise stimulus also has advantages, however. One of the key strengths of this type of stimulus is that it provides a linear estimate of the operation of a nonlinear system. For example, many systems experience changes in their frequency response relative to the drive level or relative to the direction of a sine-wave sweep. Random noise, which has no sweep direction and has random amplitudes at all frequency components, provides an average of the drive-level and sweep-direction effects, so it usually provides a good approximation of a system's operation.

In situations in which initial measurements indicate that the energy level of the random-noise stimulus is too low, you can improve the relative power spectral density of the stimulus by reducing the frequency span of the measurement (if the analyzer uses a band-limited random-noise source). However, to cover the original frequency span of interest, you must take more measurements.

Single- vs multiple-band analysis

The SFA's single-filter measurement process is slower than the FFT process, which provides hundreds of filters. However, the use of a single filter does have its advantages. If you use a single filter, you can make all the signals produced by distortion products (such as harmonic distortion and intermodulation distortion) lie outside the analysis bandwidth of a single filter, thus removing the products from the measurement.

By increasing the Fourier integration time, you can always reduce the filter's bandwidth to exclude distortion products **(Fig 6).** The only time you can't remove a disturbance signal is when a spur at a fixed frequency occurs at exactly the same frequency as that of the SFA's stimulus. Because of its many filters, the FFT process can be affected by distortion products, depending on the stimulus used.

For example, if you use a sine-wave stimulus in a

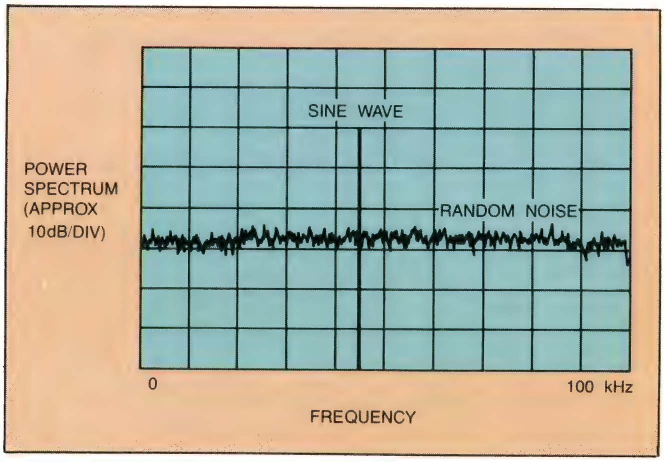

Fig 5—Power-spectrum density for a random-noise signal *is much lower than that for a sine wave, as this plot shows. The random-noise signal distributes its energy over a much wider bandwidth than does a sine wave.*

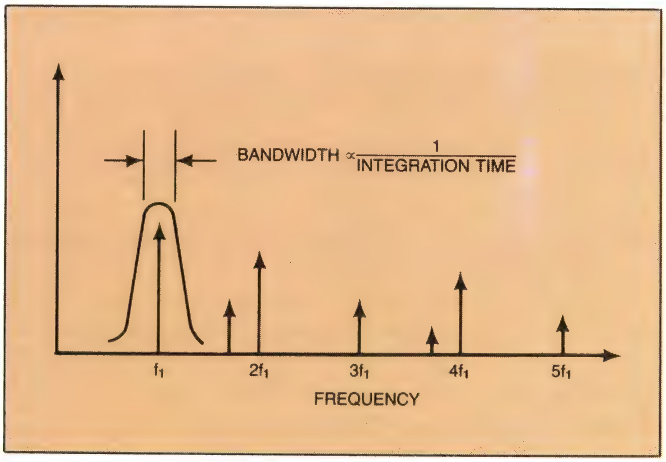

Fig 6—Reducing the analysis band of an SFA's measurement process *excludes distortion products from the measurement. The analysis band is inversely proportional to the Fourier integration time.*

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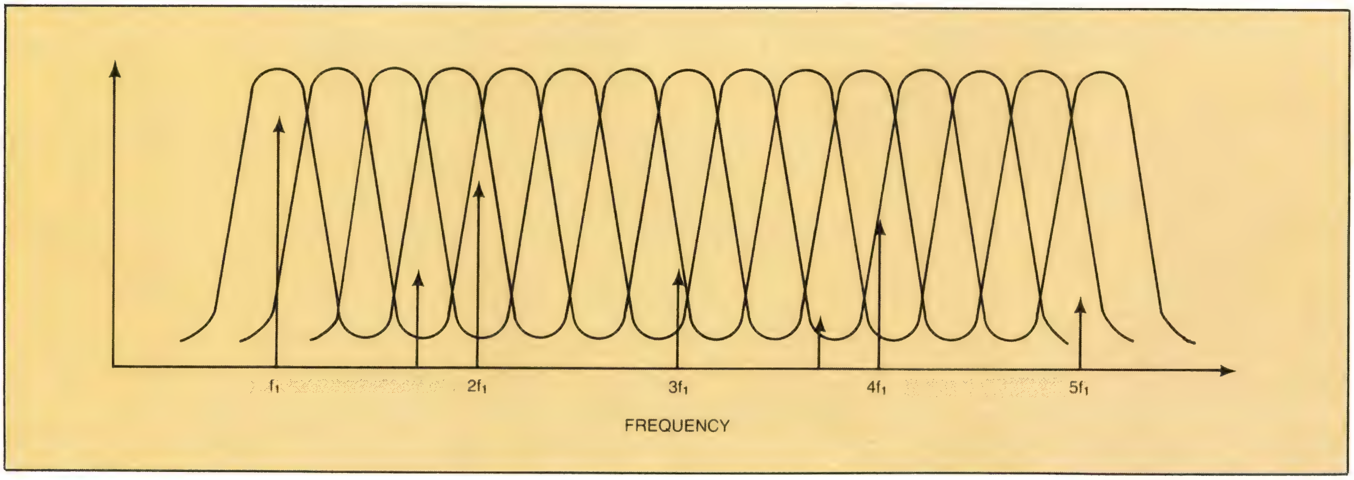

Fig 7—A sine-wave stimulus in a measurement using the FFT process *can cause distortion products to appear within the filters produced by the transforms. The products would thus be recorded as part of the system's response.*

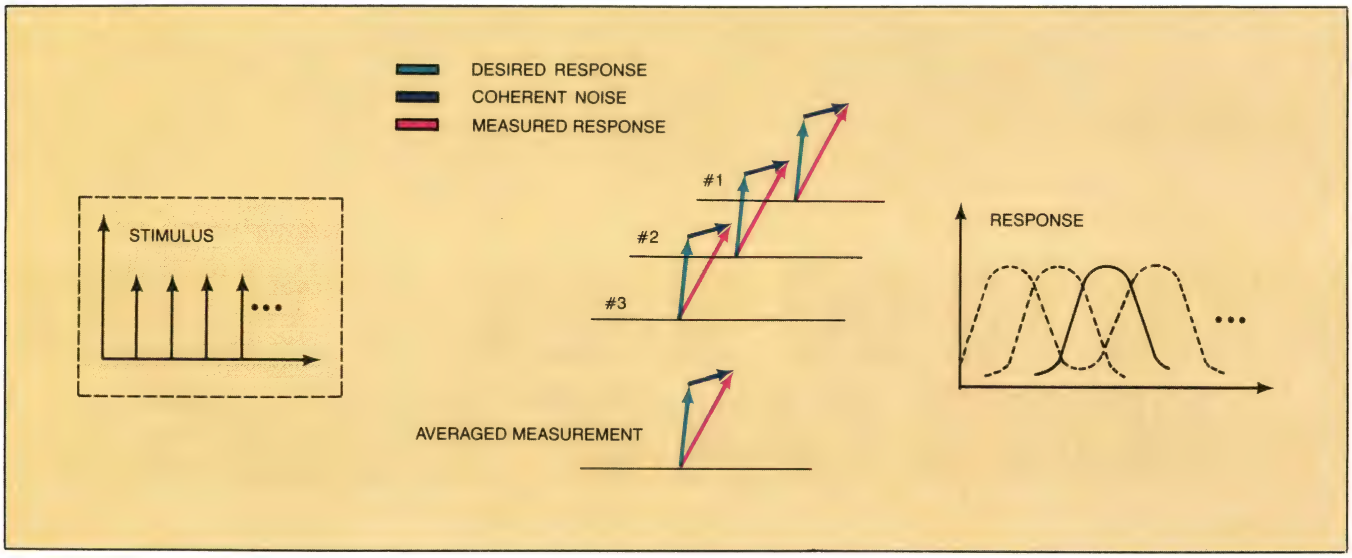

Fig 8—Periodic stimuli allow harmonics to maintain a constant phase relationship *with desired signals. It's impossible, therefore, to average these components to zero, thereby reducing the effect of the nonlinearity on a measurement. A random stimulus eliminates this distortion-induced problem; averaging causes the nonlinear portion of the response in each filter to dwindle to zero.*

system that produces harmonic distortion, the distortion products can appear within one or more of the FFT's filters and be recorded as part of the system's response **(Fig 7)**.

Distortion products can also affect the FFT process when you use a pseudorandom signal as a stimulus. You can characterize this pseudorandom signal as a summation of discrete sine waves, each of which is tuned to the center frequency of a unique filter. If you separate the response in each filter into the portion of the response that results from the intended stimulus (the desired response) and the portion of the response that arises from a harmonic product of a lower frequency, you'll never see a change in the relationship between the desired response and the distortion product from measurement to measurement. Therefore, even if you were to average the results of several measurements, you wouldn't reduce the effect of the nonlinearity on the measurement **(Fig 8)**.

A random stimulus, however, eliminates this distortion-induced problem by letting the nonlinear portion of the response in each filter decay to zero with averaging, even if the nonlinearity is a fixed spur at the center frequency of a filter. A swept-sine-wave stimulus

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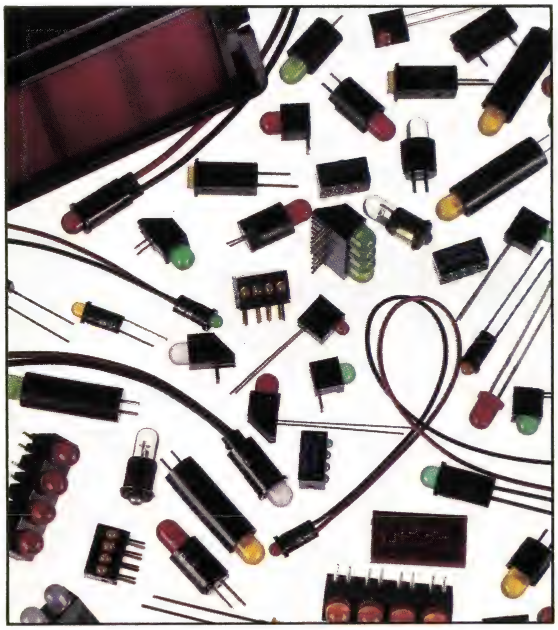

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An FFT analyzer uses two channels to compare input and output and emulates hundreds of bandpass filters to provide complete coverage of an entire spectrum.

doesn't permit such averaging. The explanation of distortion phenomena leads directly to the topic of noise reduction.

Noise reduction in SFAs and FFTs

The noise-reduction process of SFAs is fairly straightforward. If you increase the integration time in each channel, the analysis bandwidth in each channel becomes smaller and smaller while remaining centered on the frequency of the stimulus. As the bandwidth becomes smaller, the noise power (of the measured system) within the filter lessens. Moreover, any spurs close to the center frequency become located farther down the stop band of the analysis bandwidth until they receive sufficient rejection.

The only type of distortion that can't be rejected is a spur that has the same frequency as the stimulus and that maintains a constant phase relationship with the stimulus. In this case, the spur is said to be coherent with the stimulus. A key aspect of this type of noise reduction is that the noise in each channel is reduced before the gain and phase relationship (ie, the frequency response) between channels is calculated.

The FFT process makes two types of noise reduction available: time averaging (a form of linear averaging) and power-spectrum averaging. Time averaging is very similar to the SFA's averaging process in that it improves the S/N ratio of the signal in each channel before the frequency response is calculated. The time-averaging method gathers the samples of the signal normally considered by the FFT into blocks of data called time records, and then averages the time records.

To keep averaging from reducing the signal of interest, you must make sure that the signal is a periodic one (such as the pseudorandom signal mentioned above) and that the phase of the signal is the same in each time record. You must also supply a trigger signal to the analyzer to indicate when data collection should begin.

Power-spectrum averaging

The second, and more commonly used, form of noise reduction in FFT measurements is power-spectrum averaging. The fundamental difference between this technique and time averaging is that relatively little

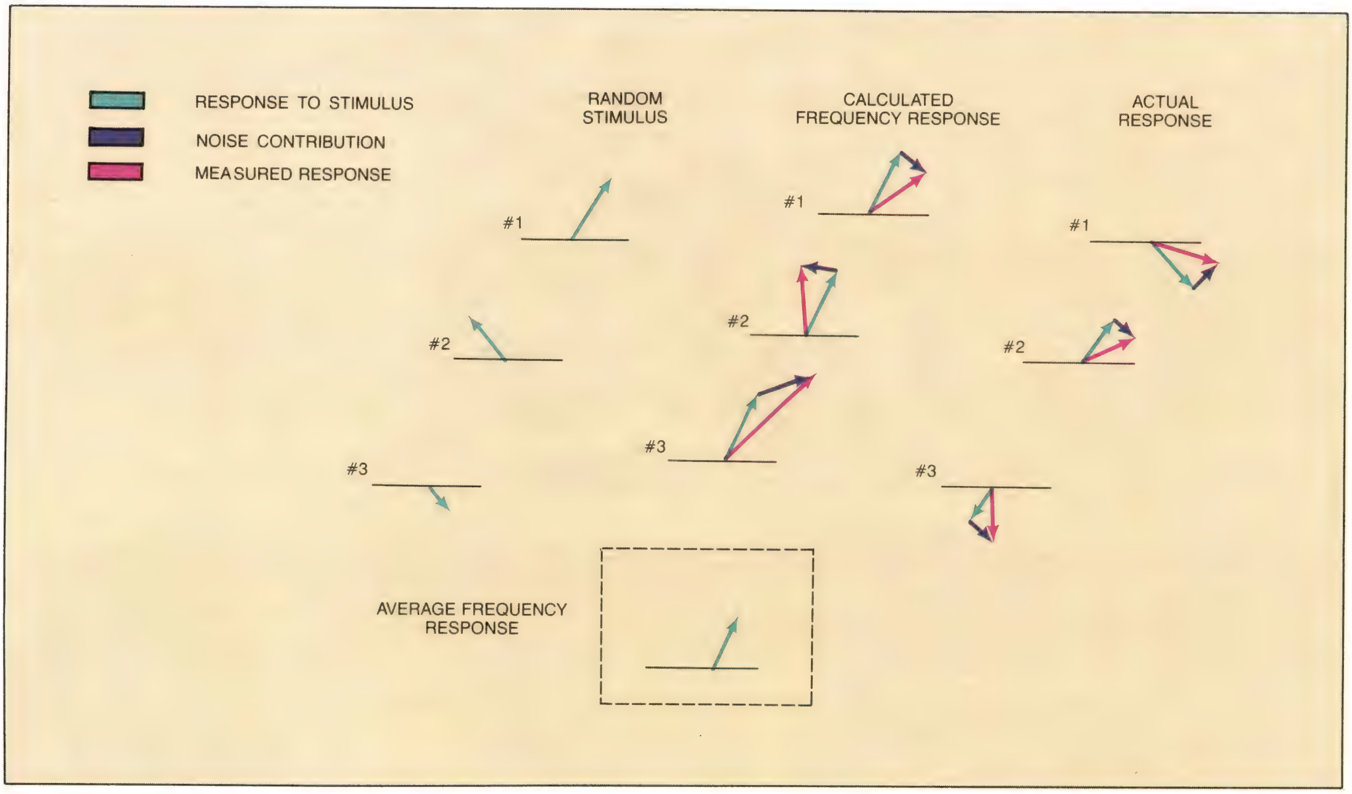

Fig 9—If you average frequency-response calculations, *you can use random noise as a stimulus. The stimulus-response relationship remains constant, while the noise contribution in both channels averages to zero. The averaged frequency response thus converges in a linear representation of the system's frequency response.*

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If you don't understand the differences in the ways an FFTA and an FRA effect measurement-noise reduction, you could misuse the FFTA.

noise reduction occurs in each channel. Instead, the method removes noise by averaging frequency-response data from each measurement.

The benefit of this noise-reduction technique is that it doesn't matter how much the stimulus signal differs from one measurement to the next, as long as the gain and phase relationship from measurement to measurement remains the same. You can thus use random noise in an averaged measurement.

For example, assume you allow the random-noise stimulus to maintain the same frequency components as the pseudorandom-noise signal discussed earlier, but let the phase of the discrete sine waves vary randomly (a poor representation of random noise, but useful for this example). In this case, the stimulus signal within each filter will have a different phase orientation in each measurement.

If you were to examine a filter whose output is composed of a linear response to the intended stimulus signal and a nonlinearity-induced harmonic product, you'd see a change from measurement to measurement in the relationship between the linear response and the harmonic. The disparity exists because the phase of the harmonic's fundamental and the intended stimulus would have changed between measurements.

If, over several measurements, you examine a vector representing the computed frequency-response data for each measurement, you'll see that the distortion product appears as a vector that rotates about the end of a stationary frequency-response vector **(Fig 9).** When you average several frequency-response vectors, the contribution from the distortion product falls to zero. The averaged frequency-response vector thus gives you the best linear estimate of the device's frequency response. If you use a random-noise stimulus in this type of averaging scheme, you'll find that even a spur at the center frequency of a filter would be noncoherent with the stimulus and would average to zero.

Although power-spectrum averaging, combined with a random-noise stimulus, reduces the effects of all forms of distortion products from a measurement, you wouldn't benefit from using power-spectrum averaging with a periodic stimulus. Using a periodic stimulus would allow distortion products to be coherent with the stimulus, so they'd be unaffected by averaging. Further, certain control-system measurements don't allow the use of power-spectrum measurement.

The FFT analyzer is always better than a swept-frequency analyzer for measuring a basically linear system with poor to good S/N conditions. Both analyzers (FFTA and SFA) will provide the same response, but the FFT process will provide it much more quickly. The SFA, on the other hand, gives you the best possible S/N ratio, so it's more suitable for use in difficult measurement situations. Having both techniques available is clearly preferable, as in a DSA, so you can use them to handle different measurement problems. **EDN**

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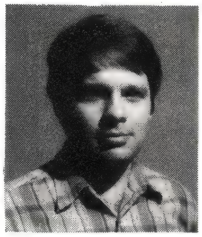
Authors' biographies



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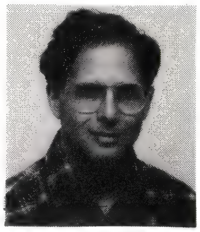

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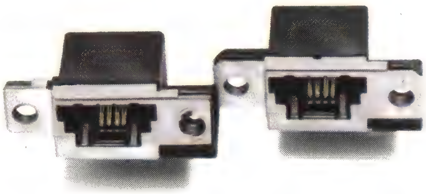
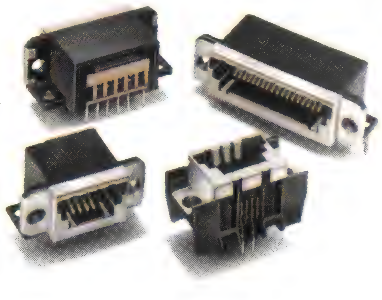


Top or side entry pcb receptacles. Integral shunt versions and side-entry versions with offset mounting ears for close spacing also available.



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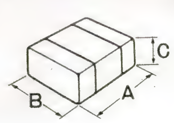
A wide range of capacitances and high dimensional accuracy are instrumental in the production of slim, high-density, quality boards.

Dimensions: A x B x C (mm)	Class I (50V)						
	CH	PH	RH	SH	TH	UJ	SL
3.2 x 1.6 x 0.6~1.1	0.5~ 680pF	0.5~ 820pF	0.5~ 1,000pF	0.5~ 1,200pF	0.5~ 1,520pF	0.5~ 1,500pF	0.5~ 2,700pF
2.0 x 1.25 x 0.6~1.1	0.5~ 430pF	0.5~ 560pF	0.5~ 680pF	0.5~ 750pF	0.5~ 820pF	0.5~ 1,000pF	0.5~ 1,800pF

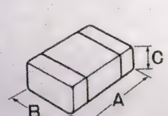
Dimensions: A x B x C (mm)	Class II	
	50V	25V
3.2 x 1.6 x 0.6~1.1	1,000~ 100,000pF	12,000~ 220,000pF
2.0 x 1.25 x 0.6~1.1	470~ 47,000pF	6,800~ 100,000pF



Multi-layer Chip Inductors (MLF Series)

Coilless chip inductors utilizing TDK's multi-layer ferrite technology. Closed magnetic paths for perfect shielding.

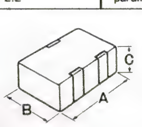
Dimensions: A x B x C (mm)	Inductance (μH)
3.2 x 1.6 x 0.6	0.1~1.2
3.2 x 1.6 x 1.1	0.39~27
3.2 x 2.5 x 1.1	33~56
3.2 x 2.5 x 2.5	68~220

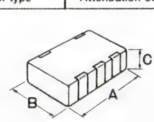


Multi-layer Chip Transformers, IFT, LC Traps

With the world's smallest transformers, IFT and LC traps (series 4532), TDK advances automated surface mounting by another significant step. Monolithic IFT and LC traps incorporating non-adjustable transformers and capacitors in a single, sintered, multi-layer block. Another world's first from TDK.

Series designation Dimensions: A x B x C (mm)	Applicable frequency range	Characteristics
MTT (transformers) 4.5 x 3.2 x 2.8	300kHz~1MHz	L: 10~200μH
MIA (AM IFT) 4.5 x 3.2 x 2.5	455kHz, 459kHz 464kHz	Q: above 40
MIF (FM IFT) 4.5 x 3.2 x 2.0	10.7MHz	Q: above 40
MXT (LC traps) 4.5 x 3.2 x 2.2	in-series type parallel type	F±2% Attenuation over 20dB

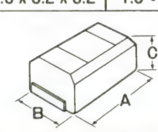




Leadless Inductors (NL & NLF Series)

Especially suitable for automatic high-density mounting. Epoxy sealed, excellent dimensional accuracy, large inductance, steep Q. High temperature and humidity resistance.

Series designation, Dimensions: A x B x C (mm)	Inductance range (μH)	Q
NL 3.2 x 2.5 x 2.2	0.12~100	20~30
NL 4.5 x 3.2 x 3.2	1.0~1,000	30~50
NLF (shielded) 4.5 x 3.2 x 3.2	1.0~1,000	30~50



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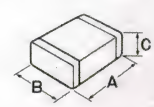
Dimensions: A x B x C (mm)	Impedance (Ω) at 100MHz	DC resistance Rdc (Ω)
2.0 x 1.25 x 0.9	5~9	0.030~0.033
3.2 x 1.6 x 1.1	14~26	0.048~0.055
3.2 x 2.5 x 1.3	37~77	0.105~0.121
4.5 x 3.2 x 1.5	55~130	0.193~0.212



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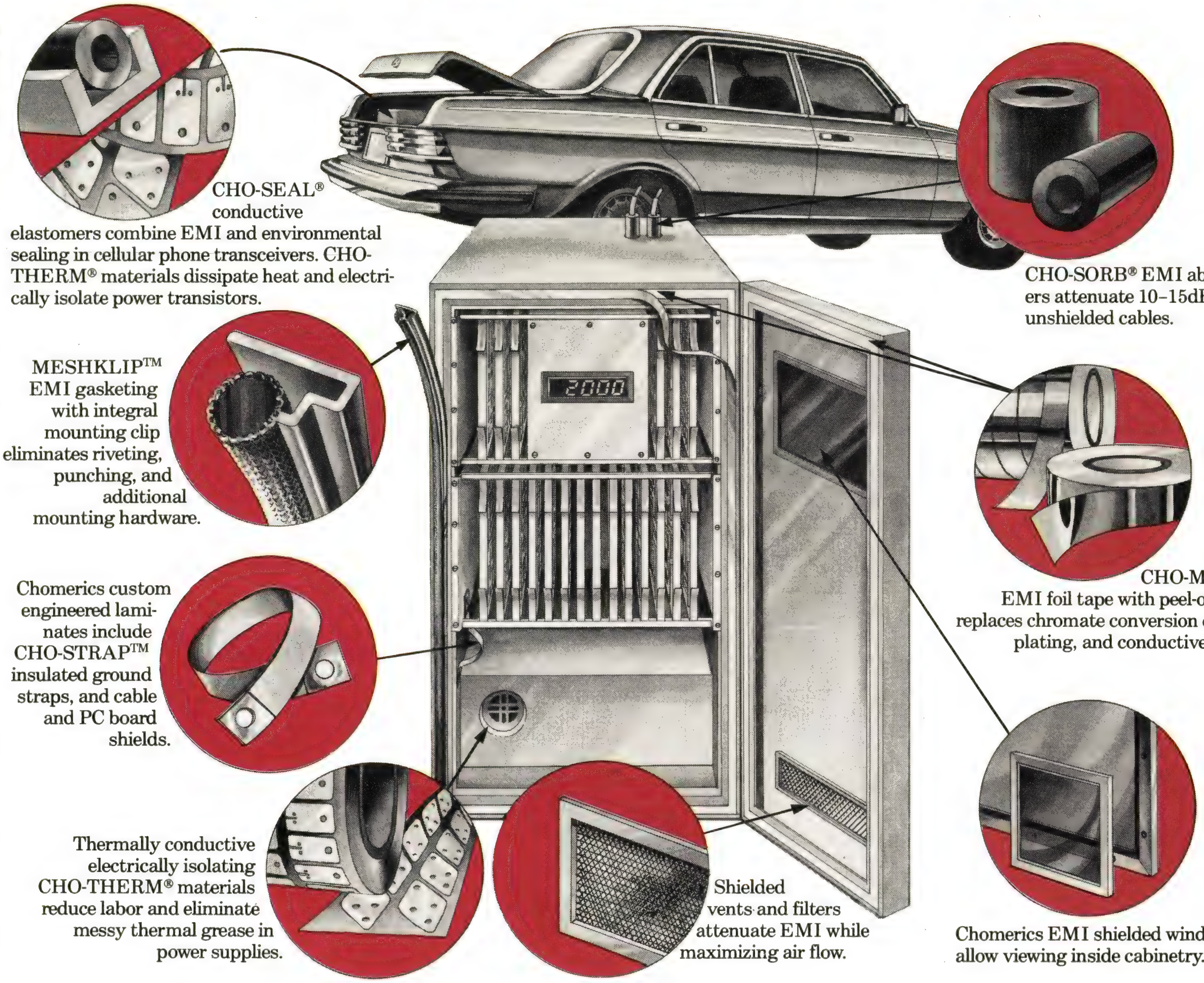

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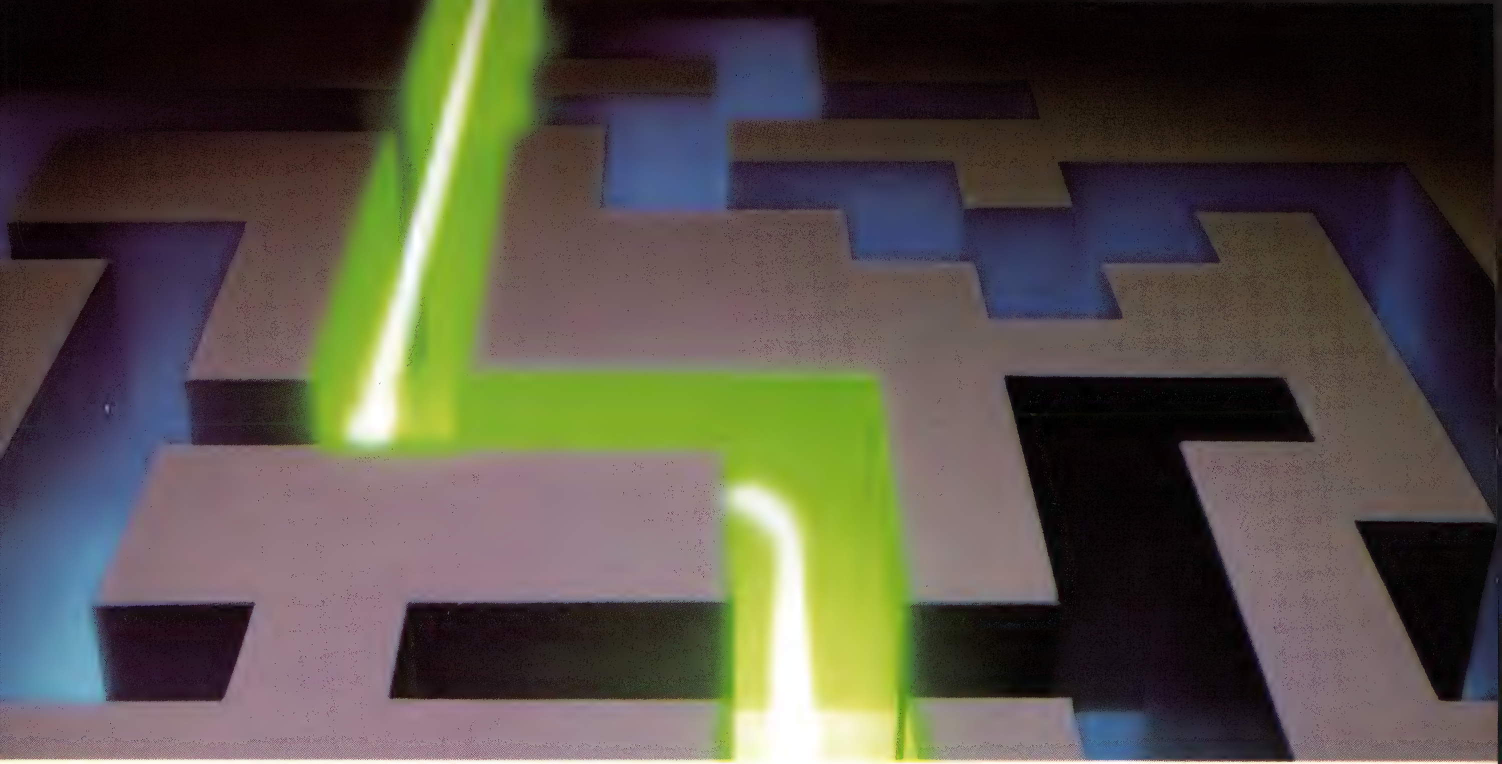

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EDITED BY TARLTON FLEMING

Dual one-shot forms frequency discriminator

Gordon F Rogers
Bradenton, FL

Circuits that include a dual, retriggerable, monostable multivibrator let you sense a frequency threshold **(Fig 1)** or sense when a frequency f_{IN} is within preset bounds **(Fig 2)**.

For threshold sensing, you configure IC_{1A} **(Fig 1)** as a retriggerable pulse generator of frequency f_R by selection of an external resistor and capacitor (f_R=30 Hz in this case). V_{OUT} is low when f_{IN} is less than f_R, but the duty cycle of IC_{1A}'s Q_1 output increases to 100% (dc) as f_{IN} increases. For this dc condition, Q_1 is high and $\overline{Q}_2$ is high, so V_{OUT} is high, indicating f_{IN} is greater than f_R.

The 1-kΩ resistor delays the Q_1 output slightly to compensate for the propagation delay through IC_{1B}, which will otherwise cause brief output pulses at the f_{IN} frequency. *(Ed Note: To get enough delay, you may need a small capacitor (C) as well.)* **EDN**

To Vote For This Design, Circle No 750

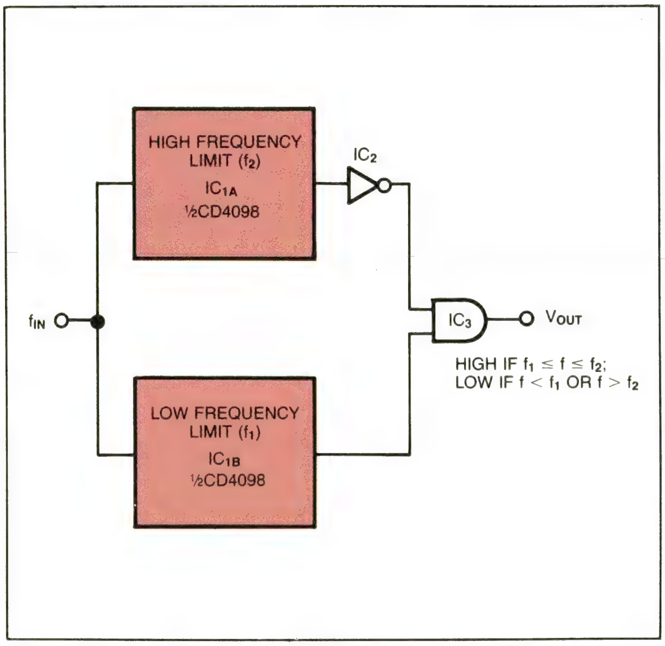

***Fig 2—Parallel one-shots form an indicator circuit** that determines whether f_{IN} is in band or out of band.*

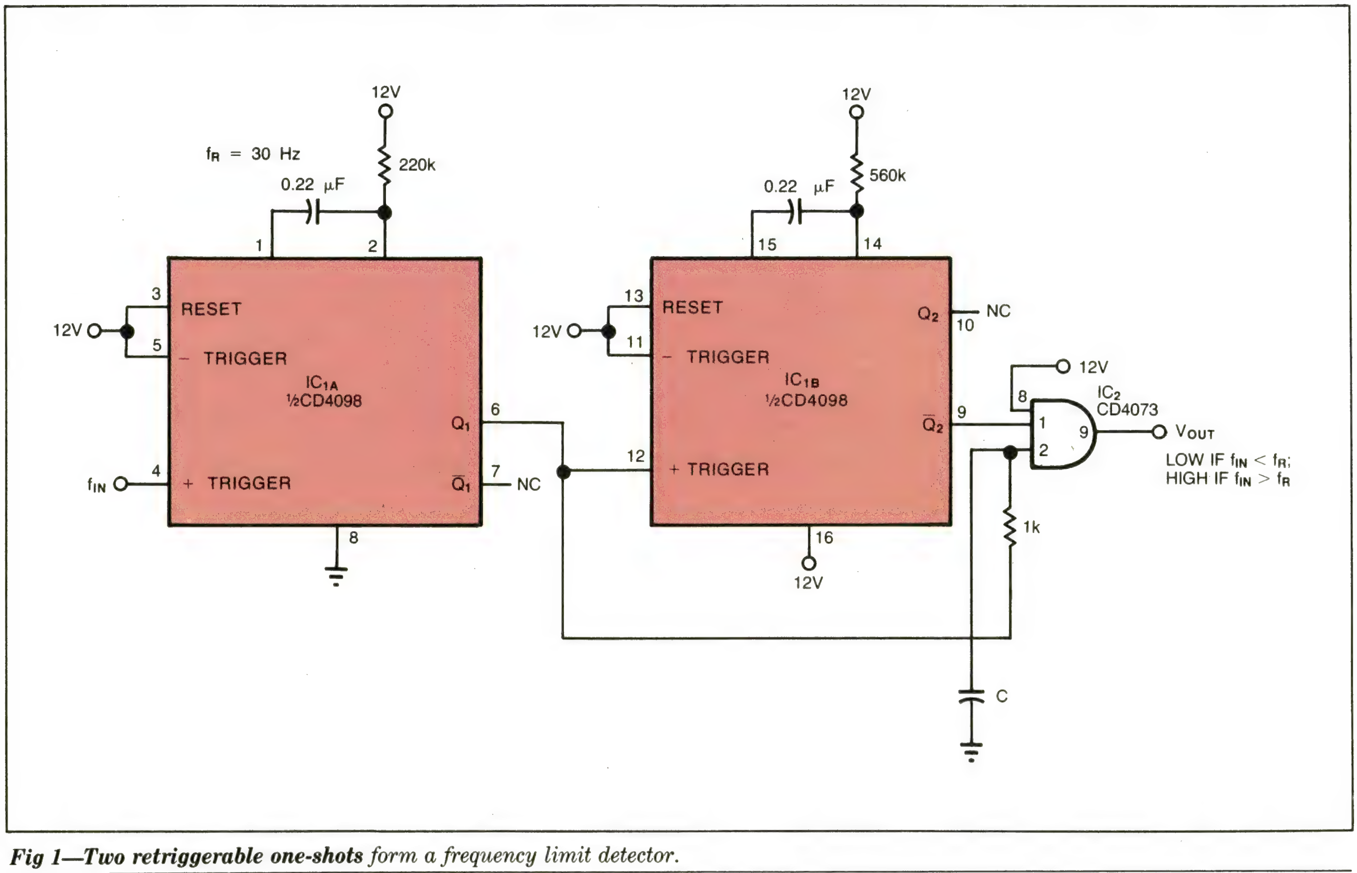

***Fig 1—Two retriggerable one-shots** form a frequency limit detector.*

Matched FETs provide balanced modulator

Richard C Cabot
Audio Precision, Beaverton, OR

The balanced modulator circuit of **Fig 1** is suitable for use with two audio-frequency signals. You can apply the carrier to either input (drain or gate port), and you apply the lower-frequency amplitude-modulating signal to the remaining input. Your choice will depend on your application; the drain input provides better feedthrough performance (−80 vs −60 dB), but is less linear than the gate input. The output is zero with either or both inputs removed.

A matched pair of FETs serves as voltage-controlled input resistors for the inverting op-amp stages IC_3 and IC_4. Because the FETs' on-resistance is inversely proportional to their gate voltage and because the op amps' gain is inversely proportional to the input-resistor value, the op-amp gain is proportional to the FET gate voltage. Further, the two 2-kΩ dividers provide a standard method of enhancing the linearity of on-resistance with respect to gate voltage. Feeding IC_3's output to IC_4's summing junction subtracts the FET source currents. And, because the same signal connects to each drain, the even-order nonlinearity products cancel—provided that the FETs are properly matched. (IC_1 buffers the drain voltage for use in this linearity compensation. You can eliminate the buffer with only a small increase in intermodulation distortion between the two port signals.)

To compensate for different pinch-off voltages in the FETs, you adjust overall gain using the 1-kΩ potentiometer in the output stage. Similarly, you compensate for small mismatches in the FETs' on-resistance by adjusting the 20Ω potentiometer near IC_3 for minimum drain-signal feedthrough while maintaining 0V at the gate port. A large resistance (2.80 kΩ) in series with the FET drains helps to mask further changes in on-resistance.

Intermodulation products between the two ports measure less than −90 dB with the signal levels shown. The gate signal's harmonic distortion is typically −60 dB and predominantly third order. You can reduce this distortion further by tying the 100-kΩ resistor to a negative voltage instead of ground, which applies negative bias to the FET gates. **EDN**

To Vote For This Design, Circle No 749

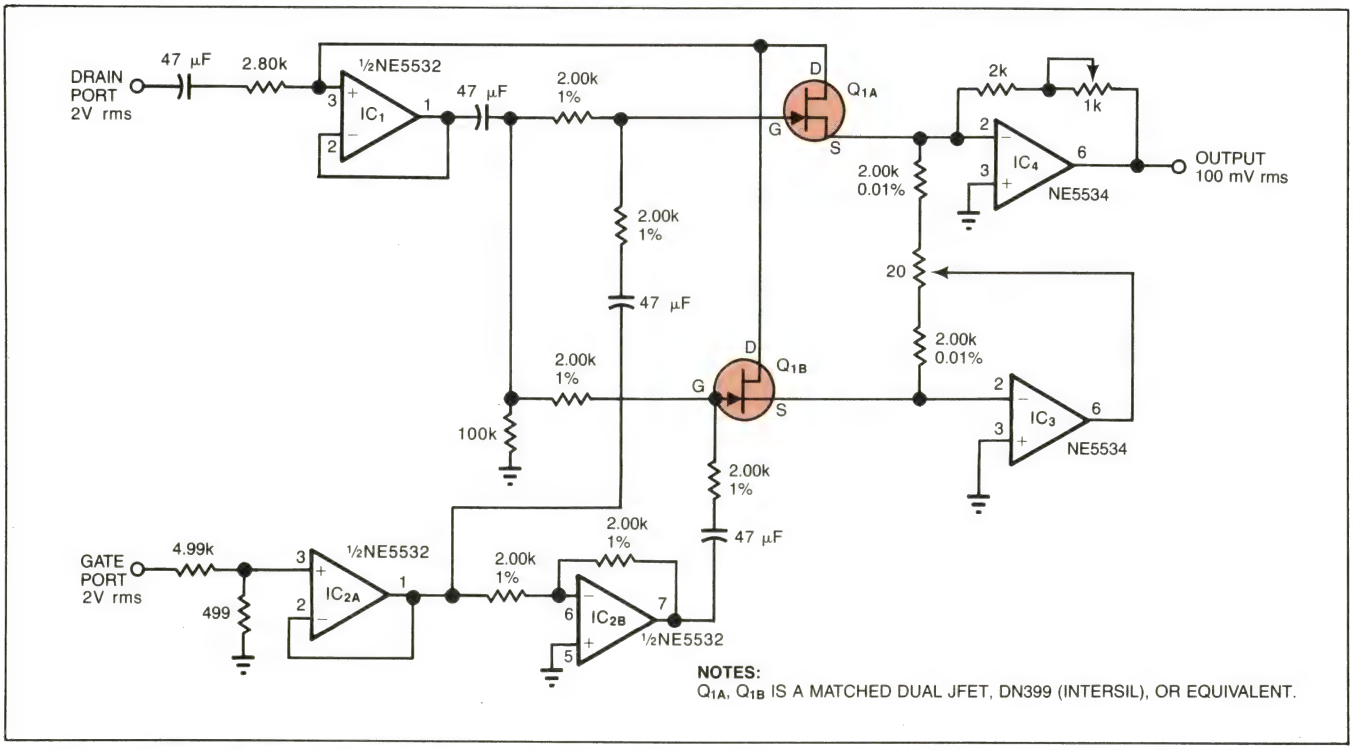

Fig 1—This balanced modulator for audio frequencies *uses the on-resistance of matched FETs as gain-control elements. Intermodulation distortion (linearity) is better than −90 dB.*

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Min. Pass Band (MHz) DC to	10.7	48	98	140	190	270	400	520	580	700	780	900
Max. 20dB Stop Frequency (MHz)	19	70	147	210	290	410	580	750	840	1000	1100	1340

Prices (ea.): P $9.95 (6-49), B $24.95 (1-49), N $27.95 (1-49), S $26.95 (1-49)

HIGH PASS Model *HP–	50	100	150	200	300	400	500	600	700	800	900	1000
Pass Band (MHz) start, max.	41	90	133	185	290	395	500	600	700	780	910	1000
Pass Band (MHz) end, min.	200	400	600	800	1200	1600	1600	1600	1800	2000	2100	2200
Min. 20dB Stop Frequency (MHz)	26	55	95	116	190	290	365	460	520	570	660	720

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CIRCLE NO 209

C105 REV. ORIG.

Lamps improve solenoid-driver efficiency

John A Haase
Colorado State University, Fort Collins, CO

A simple solenoid driver **(Fig 1)** uses incandescent-lamp filaments to limit power consumption. As a welcome side effect, the lamps also serve as on-indicators.

High magnetic reluctance (opposition to flux) in the coil of an armature-driven device (solenoid, relay, etc) calls for a surge of activation current, followed by a lower dc level to remain on (surge to on-current ratio is typically 5:1). You can roughly approximate this current requirement by connecting a lamp filament in series with the coil. The cold filament allows a surge of coil-activation current to pass through; as the filament heats up, it throttles the current to a more reasonable hold value.

The solenoid driver circuit in **Fig 1** offers these features:

- 5V logic swings turn the power-MOSFET switch (Q_1) fully on and off.
- Two low-cost flashlight lamps in parallel handle the peak current. Because their dc current is only 50% of peak and because they operate at 60% of their rated voltage, the lamps have an operating life of 12,000 hours. Further, the lamp filaments' positive temperature coefficients raise each filament's resistance, which eliminates current-hogging problems and provides short-circuit protection.
- Steady-state on-current is 700 mA (vs 1700 mA without the lamps).
- A 4.6V min supply rating allows battery operation.

EDN

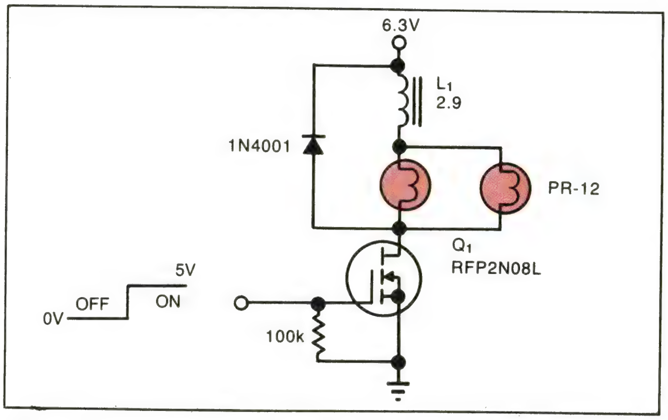

***Fig 1—This solenoid driver uses PR-12 flashlight lamps** to limit the coil's on-current. Five-volt logic swings control power MOSFET Q_1.*

To Vote For This Design, Circle No 746

Switching supply is small and efficient

Doug Farrar
Apple Computer Inc, Cupertino, CA

Using inexpensive components, you can build a 15W (3A at 5V) switching supply **(Fig 1)** that fits easily on a 2×3-in. area of a pc board. The circuit converts 12V to 5V±2% and has an efficiency greater than 85%. Further, a bootstrap technique ("Circuit improves switcher's efficiency," EDN, September 19, 1985, pg 242) allows the use of an efficient n-channel power MOSFET as the switching transistor.

Components R_1 and C_1 set the operating frequency (100 kHz) of PWM switching regulator IC_1. This regulator controls the switching transistor (Q_1) via a bootstrap network consisting of Q_2, Q_3, R_2, R_8, D_1, D_2, and C_2. Bootstrapping provides approximately 23V of gate drive and thus permits use of a MOSFET (Q_1).

The main output filter consists of the lowpass network L_1, C_6, C_7, and C_8. L_2 and C_9 provide additional lowpass filtering for higher frequencies, and the resulting output ripple is less than 100 mV p-p. The inductors are wound on low-cost powdered-iron torroids to minimize the generation of external magnetic fields.

If Q_1's source current exceeds 4A (corresponding to a dc load current of about 3.5A), the voltage across R_3 and R_4 causes IC_1 to enter its current-limit mode. The Schottky rectifier D_3 functions as a catch diode to improve regulation efficiency.

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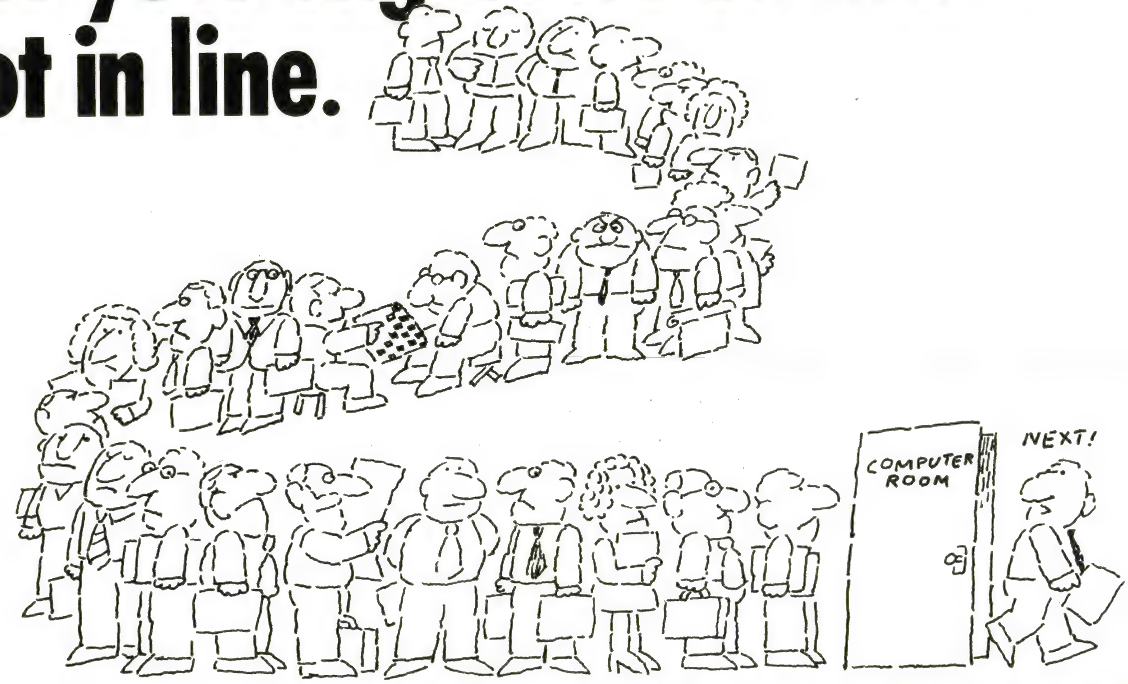
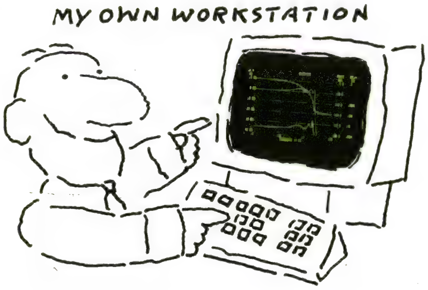
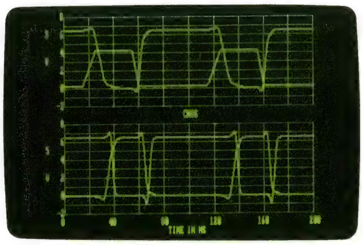
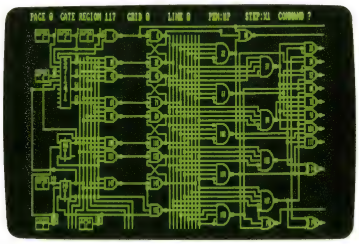






"Typical MICROCAP Transient Analysis"



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MICROCAP II lets you be even more productive. As an advanced version, it employs sparse matrix techniques for faster simulation speed and larger networks. In addition, you get even more advanced device models, worst case capabilities, temperature stepping, Fourier analysis, and macro capability.

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MICROLOGIC provides you with a similar interactive drawing and analysis environment for digital work. Using standard PC hardware, you can create logic diagrams of up to 9 pages with each containing up to 200 gates. The system automatically creates the netlist required for a timing simulation and will handle networks of up to 1800 gates. It provides you with libraries for 36 user-defined basic gate types, 36 data channels of 256 bits each, 10 user-defined clock waveforms, and up to 50 macros in each network. MICROLOGIC produces high-resolution timing diagrams showing selected waveforms and associated delays, glitches, and spikes—just like the real thing.

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CIRCLE NO 210

An RC network (R_5, R_6, R_7, C_3, C_4, and C_5) provides frequency compensation for the regulator loop. Loop gain is 36 dB at 60 Hz, 30 dB at 120 Hz; phase margin is 60° at unity gain (4.5 kHz).

The regulator generates little heat. Without a heat sink, Q_1's case temperature rises about 14.5°C/A of load current. With a small heat sink (in this case a Thermalloy THM 6025), the rise is about 9°C/A. **EDN**

To Vote For This Design, Circle No 747

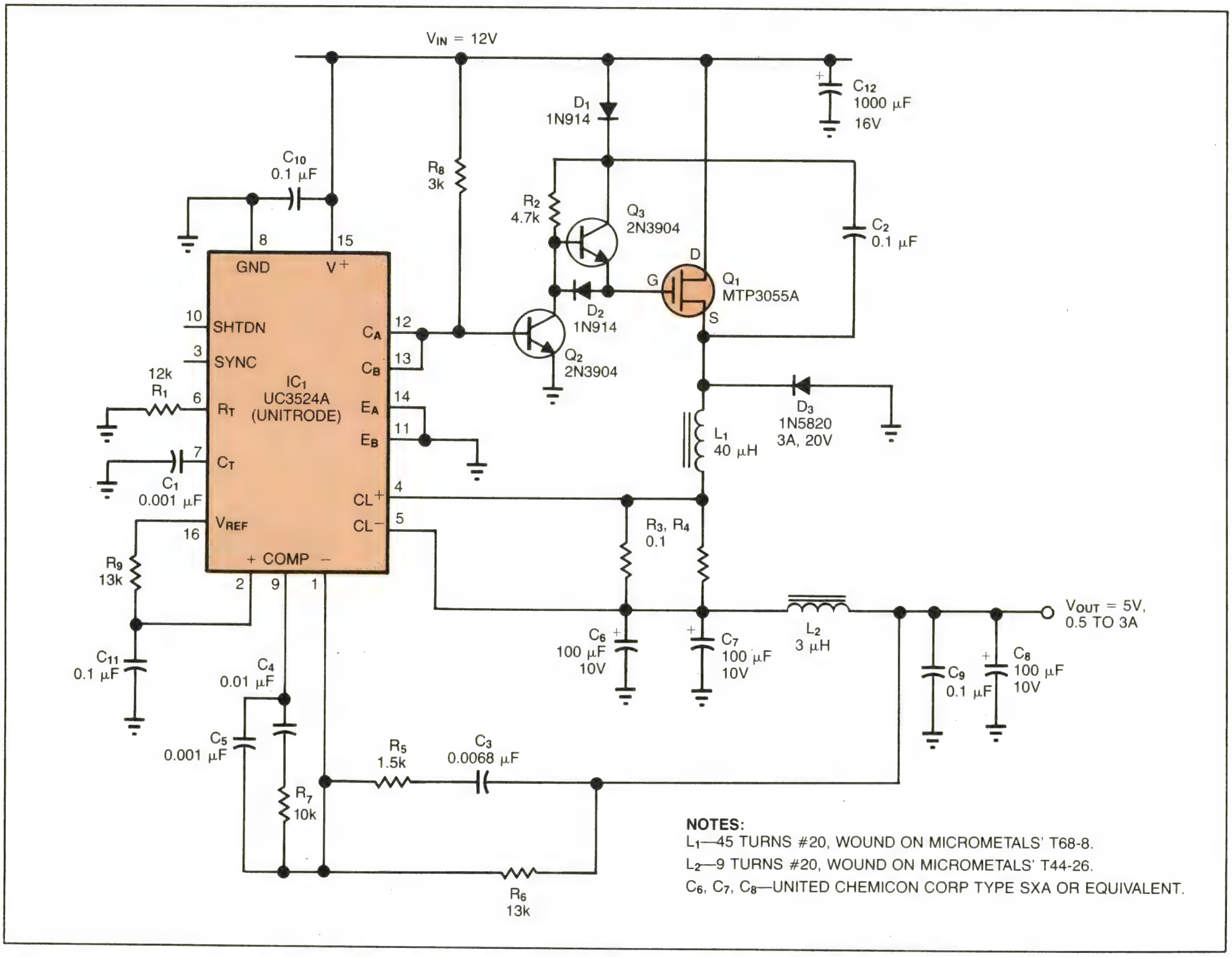

***Fig 1—A switching regulator** uses a PWM regulator IC and, for the switching transistor, an efficient n-channel MOSFET. The circuit converts 12V to 5V±2% and boasts better than 85% efficiency. (At 1A, efficiency is about 88%.)*

Square-root algorithm is fast and simple

Robert D Grappel
MIT Lincoln Laboratory, Lexington, MA

Most software routines for the calculation of square roots are based on the Newtonian-iteration algorithm or the shift-and-subtract algorithm. Shift-and-subtract routines are usually written in assembly language and are therefore fast, whereas the Newtonian-iteration routines are easy to express in high-level languages, but run somewhat slower. A third algorithm, however,

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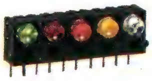
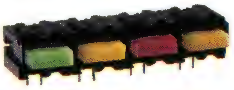
1 *Here's a new angle on right angle LED mounting. Our StatusPak™ system lets you mount from one to 12 right angle LEDs as a single unit. Choose from over 500,000 combinations of 10 LED colors, brightness intensities up to 60mcd, wide or narrow viewing angles and positioning. Select T-1 or T-1¾ LEDs.*



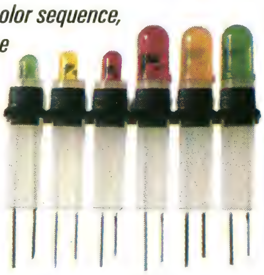
Each StatusPak is unitized and vibration resistant to ensure maximum stability during and after mounting. Housings are black to provide high contrast with LEDs.

2 *StatusPak also is available with rectangular LEDs, in your choice of vertical or horizontal positioning. Ideal for bar graphs, function and status modes, and back-lighting.*



3 *Where vertical mounting is needed, our SpaceSetter™ system reaches new heights in convenience and economy. Individual T-1 and T-1¾ LEDs feature an integral mounting spacer, provided to the exact length from .200" to .900", and ready for easy mounting. No more trouble with assembling separate LEDs and "dough-nut" type spacers.*

4 *And when you need to mount from two to 12 LEDs at a preset height, use our SpaceSetter MultiPak. We'll ship these units to you pre-assembled, arranged in any color sequence, with single-in-line or dual-in-line packaging. Perfect for through panel displays.*



5 *It is easy to see how StatusPak and SpaceSetter Circuit board indicators can help you turn mounting problems into mounting profits. Call General Instrument Lamp Division today at 312/784-1020 or write Mr. Dan Savocchia at 4411 N. Ravenswood Ave., Chicago, IL 60640. We'll send you complete information and the names of authorized distributors in your area.*

GENERAL INSTRUMENT
Lamp Division

The reasons to switch are mounting.

CIRCLE NO 211

is fast and is easy to express in a high-level language as well.

The basis for this algorithm is a mathematical theorem stating that a perfect square is equal to the sum of a sequence of odd integers, and the number of terms in the sequence gives the integer square root. (For example, the sum of the first five odd integers is 25.) The following C function shows how easily you can express this algorithm in high-level form:

```
int square_root(arg) int arg;
{
    int sq;

    if  (arg <= 0) return 0; /* special cases */
    for (sq = 1; sq < arg; sq += 2)
        arg -= sq;
    return ((sq + 1)/2); /* round count */
}
```

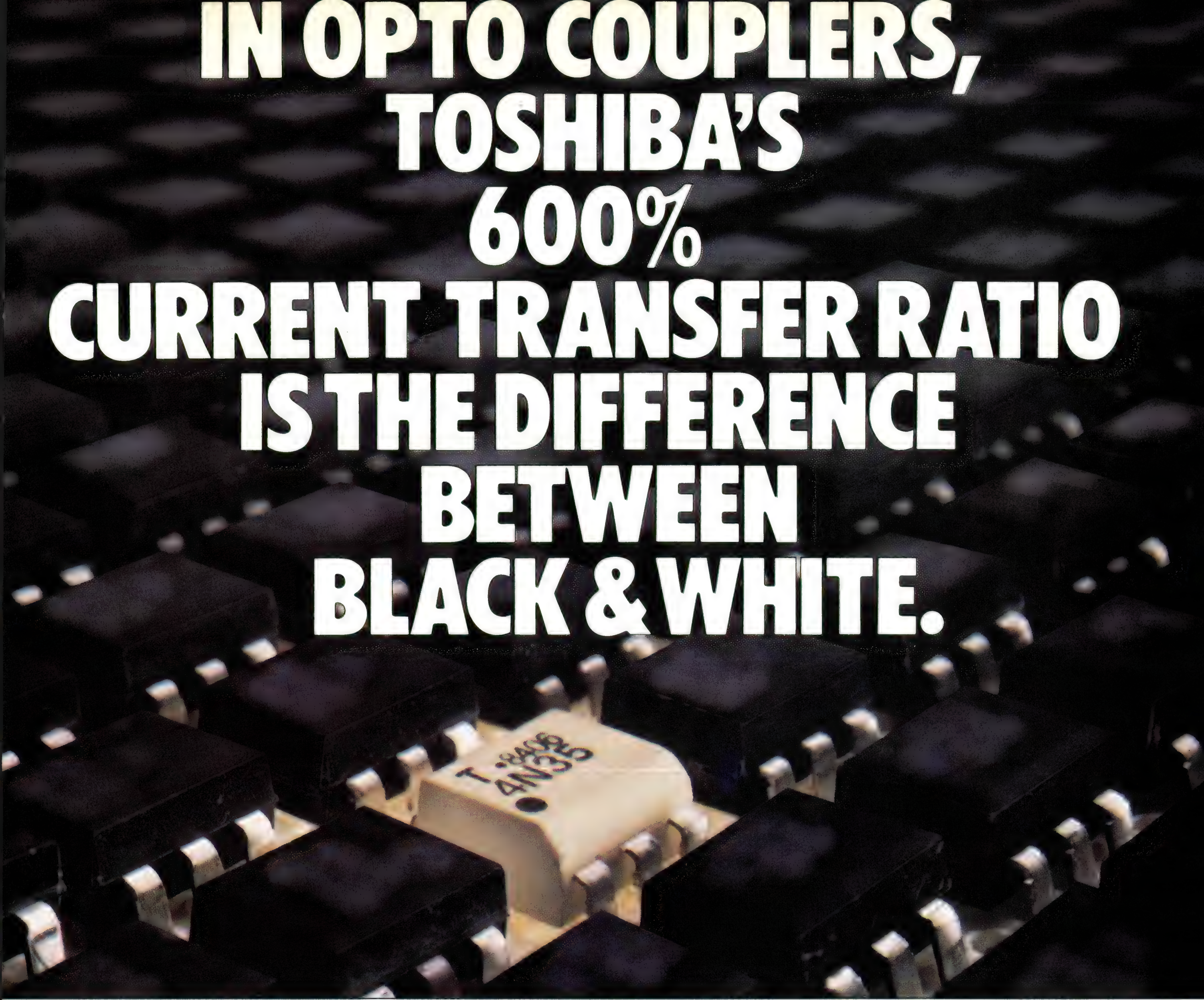
This routine returns a square-root value quickly for small arguments, but slows as you increase the size of the argument.

You can also code this algorithm very efficiently in assembly language, as illustrated in the following subroutine for the 68000 µP:

```
SQRT     TST.L D0               ARGUMENT == 0?
         BEQ.S SQRTN            YES, RETURN IT
*
         MOVE.L D1,-(A7)        SAVE D1
         MOVEQ #-1,D1           INIT. ODD
*
LOOP     ADDQ.L #2,D1           NEXT ODD INTEGER
         SUB.L D1,D0            DONE YET?
         BGT.S LOOP             IF NOT, LOOP
*
         ADDQ.L #1,D1           ROUND UP
         LSR.L #1,D1
         MOVE.L D1,D0           RETURN IN D0
         MOVE.L (A7)+,D1        RESTORE D1
SQRTN    RTS
```

The calling routine passes the unsigned 32-bit argument to the subroutine in register D0, and the subroutine returns the square root in that same register; all other registers are preserved. This routine requires about 100 clock periods for an argument of 4, 290 periods for an argument of 100, and 1480 periods for an argument of 4096. For comparison, a 68000 shift-and-subtract routine (*Dr Dobb's Journal*, May 1985, pg 122) requires between 1480 and 1832 periods, depending on the size of the argument, and it doesn't preserve the working registers. **EDN**

To Vote For This Design, Circle No 748



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DARLINGTON TR OUTPUT	TLP571 4N32				TLP571 4N32	TLP571
HIGH SPEED	TLP2601 6N135			TLP2601 6N137		
THYRISTOR OUTPUT	TLP545J TLP641J	TLP545J TLP641J				TLP541G
TRIAC OUTPUT	TLP560G TLP561G		TLP760G		TLP560G TLP561G	

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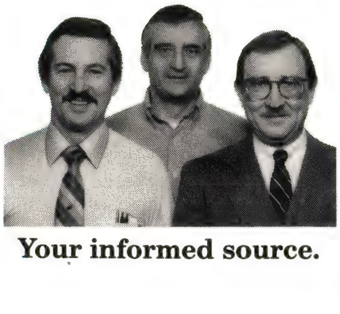

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Dept. EDN-852

CIRCLE NO 214

How to put a whole new light on your next product design.

This EL Shopping Guide comes to you courtesy of Endicott Research Group, Inc., innovators of commercially feasible Smart Force™ power for electroluminescent lighting.

EL Lamps

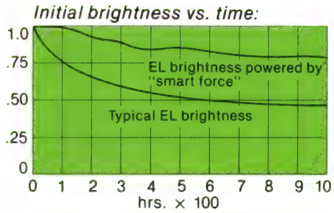
Wafer-thin, energy-efficient electroluminescent lamps, made in a variety of shapes and colors, have opened the doors on virtually limitless design options for automotive, architectural, aviation instrumentation, marine, safety, and novelty products. They're used both for primary and secondary light sources, and for signaling and decorating in a host of consumer, industrial and military applications. Throw a whole new light on your product design with EL — electroluminescence.

Liquid Crystal Displays

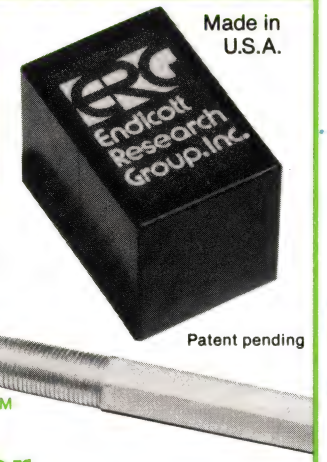
Against EL backlighting, LCD (transmissive or transflective) characters can be seen in low ambient light conditions. Particularly useful in instrument panel applications! LCD's can be ganged against large scale EL panels for multiple alphanumeric information displays which offer design and economy advantages versus CRT and screened image information displays.

"Membrane" Switches

EL backlighting enhances the aesthetics of touch-activated switches and keyboards. Creates better legibility in low ambient light conditions, too. Choose the "membrane" switch format which suits your design: flat, bubble top or keytop.



Luminescent Systems #20014-2 EL lamp (16 IN²) and ERG E613 - E0003 inverter (V IN = 12V).



Smart Force™ Power Inverter

This DC-to-AC inverter overcomes the brightness loss characteristic of EL lamps. Because it automatically adapts its own voltage and frequency over the course of EL lamp life, this Smart Force™ DC-to-AC inverter delivers constant power output, maintaining essentially constant lamp brightness. We'll be glad to help you determine the specs on your DC-to-AC inverter needs. Refer to our EL power "spec starter" sheet.

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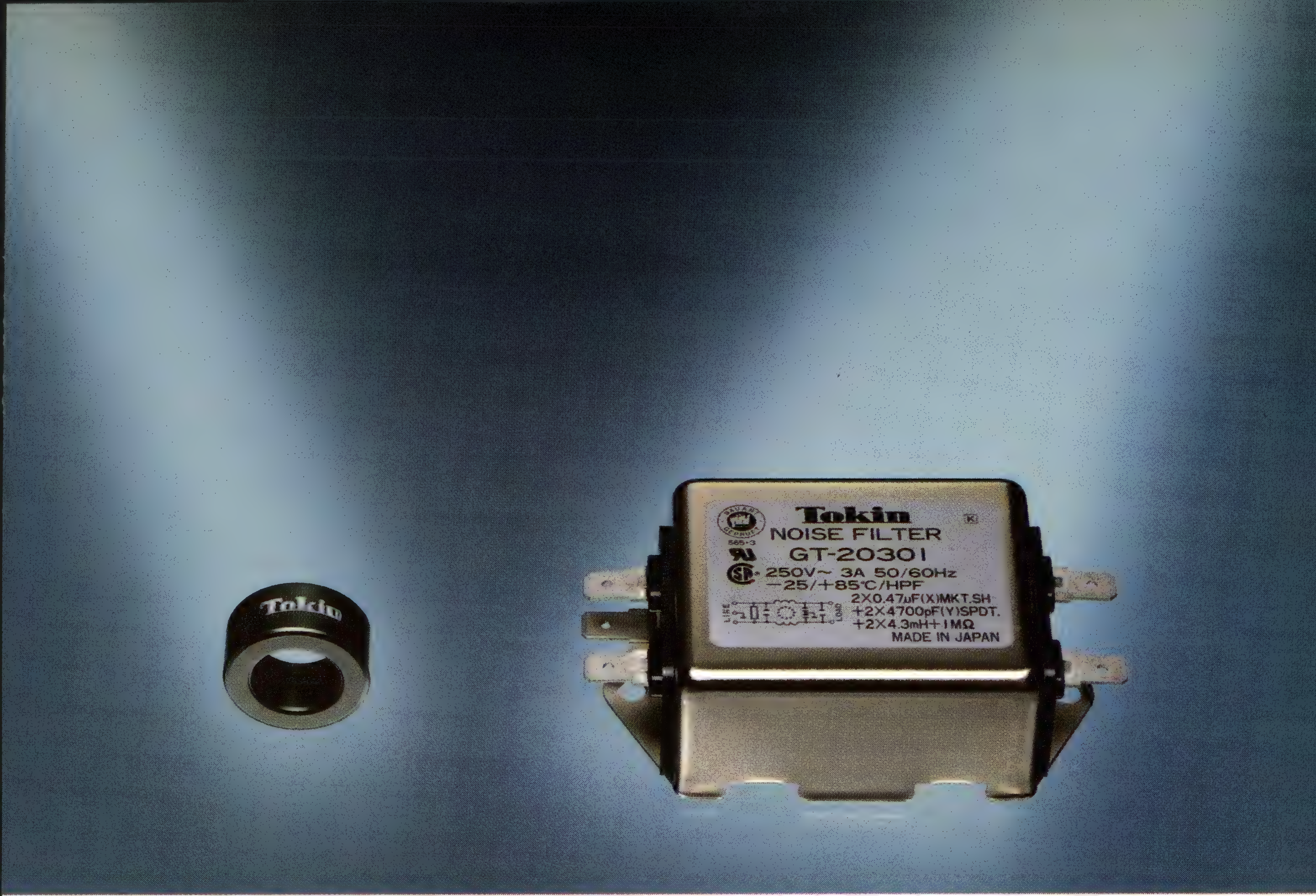

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CIRCLE NO 304

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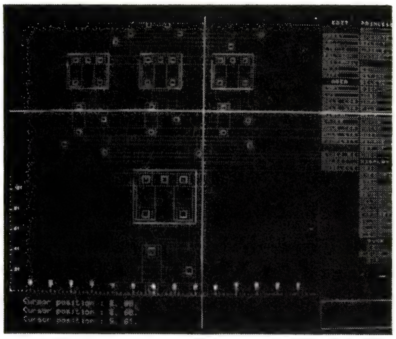
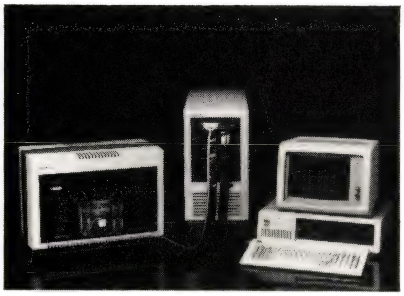


IC LAYOUT

The Princess system provides an integrated package, from schematic entry to layout, for full-custom, semicustom, standard-cell, and gate-array designs. When using the software, you perform normal input via hierarchical on-screen menus or via the keyboard. You can customize the package with programmable function keys, macrocommands, or batch files. An interface to the NCA's FDR format facilitates mask data preparation. The system runs on DEC minicomputers and workstations and on Apollo workstations. $25,000.

Silvar-Lisco, 1080 Marsh Rd, Menlo Park, CA 94025. Phone (415) 324-0700.

Circle No 350



IC TESTER

A parametric measurement unit (PMU) incorporated into the Logic Master Series allows you to measure and verify physical parameters of prototype ICs. Parameters include input current, output voltage levels, output current or drive capability, and input-voltage level sensitivity for high and low logic levels. The unit includes a switching matrix-verification station for creating a fixture for the device under test. The matrix allows the user, under program control, to disconnect the tester's drivers and receivers from the device and then connect the unit's sockets to the desired pins of the IC for measurement. A software feature, Auto-Measure, automatically develops a parametric test sequence covering every pin on the device under test. After the test has run, a report is issued with the measurement results. Two versions of the unit are available: The PMU-1001 provides a switching matrix to support as many as 192 channels; the PMU-2001 provides a matrix for as many as 384 channels. Both systems permit the user to force voltage and measure current, or to measure voltage and force current on any pin of the IC under test. PMU-1001, $19,200; PMU-2001, $31,200. Delivery, 16 weeks ARO.

Integrated Measurement Systems Inc, 9525 SW Gemini Dr, Beaverton, OR 97005. Phone (503) 626-7117.

Circle No 351

GRAPHICS DISPLAY

The 9250 terminal interfaces to the MicroVAX II. The terminal provides translucent and opaque surfaces; X-, Y-, and Z-axis clipping of objects; flat shading; depth cuing; perspective; homogeneous transformations; and surface textures, patterns, and meshes. It also edits display lists, emulates DEC's VT 100, and highlights objects. $55,000.

Megatek Corp, 9645 Scranton Rd, San Diego, CA 92121. Phone (619) 455-5590.

Circle No 352

GRAPHICS EDITOR

Rgraph performs schematic capture and physical layout of pc boards and ICs. The software supports both 1024×768-pixel and 640×400-pixel monitors and offers a selection of 16 colors from a palette of 4096. This graphics editor uses 2-letter mnemonics that relate to the English commands they represent. Libraries include TTL, CMOS, analog, and ECL. Each database can have nine libraries for source entities; each library can contain 600 entities. The package also features rubber-banding and three types of cursor controls: mouse, graphics tablet, and keyboard. It can generate output to plotters manufactured by Houston Instruments, Hewlett-Packard, CalComp, Nicolet, and Gerber. A digital simulation package is optional. $3000.

Aptos Systems Corp, 4113 Scotts Valley Dr, Scotts Valley, CA 95066. Phone (408) 438-2199.

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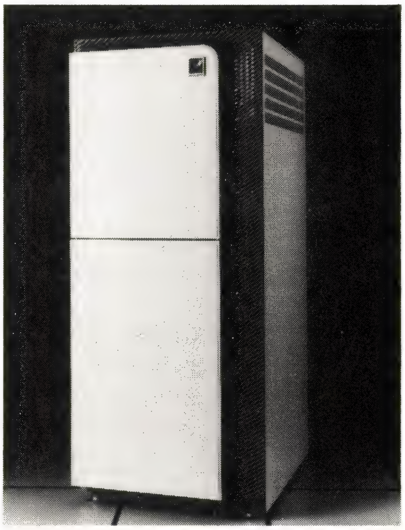

PARALLEL COMPUTER

Configurations of the Balance 21000 can include as many as thirty 32-bit processors. The computer can also include as much as 48M bytes of memory, 10G bytes of disk storage, and as many as 256 terminal lines. The system runs at speeds ranging from 2.8 to 21 MIPS. The speed of the computer increases almost linearly with the addition of processors. The Dynix operating system, a version of Unix 4.2, supports the Unix System V interface standard and user interface. $139,000 to

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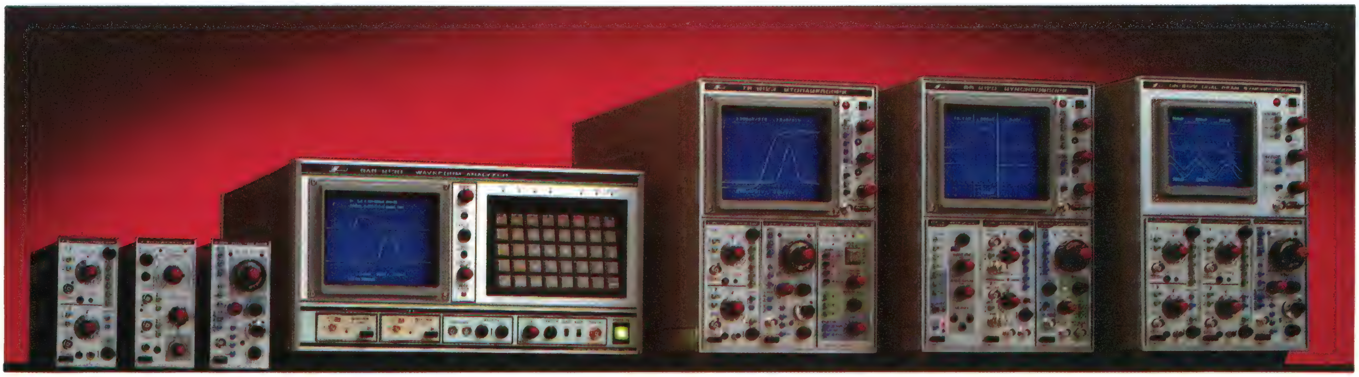

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DIGITALLY STORE 100-MHz SINGLE SHOT SIGNALS with Iwatsu TS-8123 Storage Scope. Features 3000 cm/μs writing speed, 8-bit vertical resolution, standard GP-IB and digitizing speed of 1200 cm/μs [equivalent to 40 ps (25 GHz) clock].

OBSERVE TWO SIGNALS SIMULTANEOUSLY with Iwatsu DS-8122 Dual Beam Oscilloscope with 3 plug-in compartments. The oscilloscope features 1-gun, 2-beam high luminance CRT, 100 MHz Bandwidth and digital display of data.

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$500,000; upgrade of the Balance 8000, $39,000.

Sequent Computer Systems Inc, 15450 SW Koll Parkway, Beaverton, OR 97006. Phone (503) 626-5700.

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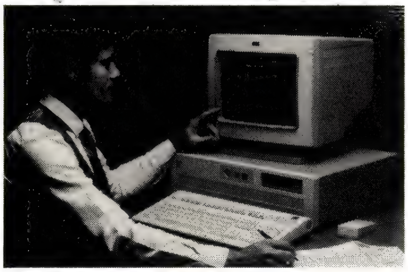


CAE WORKSTATIONS

The RT PC line of 32-bit workstations includes one desktop and three floor-standing models. The units contain a 32-bit μP that uses a RISC architecture. The workstations use the company's Advanced Interactive Executive (AIX) operating system. As many as eight users can share a single workstation's CPU. By adding a PC/AT coprocessor card and a coprocessor program, you can run programs that run on a PC and you can share the RT PC's disk files and displays with a PC. The workstation offers a choice of three graphics monitors, an 8-pen color plotter, and a tape drive. Typical stand-alone desktop unit, $16,485; typical high-end floor-standing model, $19,730.

IBM Corp, Information Systems Group, 900 King St, Rye Brook, NY 10573. Phone local office.

Circle No 355

SCHEMATIC CAPTURE

The Computer-Integrated Electrical Design Series (Cieds) runs on the manufacturer's 30XX, 43XX, PC/AT, and RT PC computers. This program, which is a port of Silvar-Lisco's schematic-capture package (Schematic Design System), can develop hierarchical logic designs on a 5080 that you have connected to a host computer. The package lets you create, edit, and list schematics and symbols. It offers multiwindow interactive graphics, net-list manipulation, and hierachical-design expansion. Interfaces are available to other automated design tools, including this company's Circuit Board Design System. Single license for mainframes, $75,000; for PC/AT, $6000; for RT PC, $8000.

IBM Corp, Information Systems Group, 900 King St, Rye Brook, NY 10573. Phone local office.

Circle No 356

SMD ANALYSIS

An SMD analysis program projects the design feasibility of an SMD

project and establishes fabrication requirements, manufacturing techniques, and design parameters. It runs on any IBM PC or compatible MS-DOS system that includes 512k bytes of RAM. $695.

Animat/USA, 200 Brown Rd, Suite 300, Fremont, CA 94539. Phone (415) 659-0105.

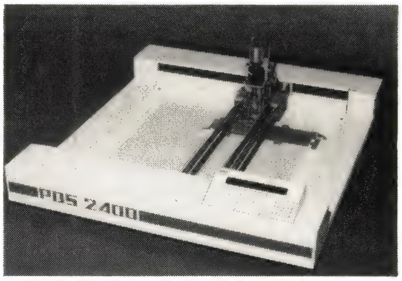
Circle No 357

PC-BOARD ROUTER

According to the vendor, the Look Out router completed the routing of a 6-layer 11×7.6-in. board that had 429 components, 1699 connections, and a 0.33 equivalent-IC density in just over 10 minutes. The router, which is part of the Scicards package, features a gridless algorithm and can route one, two, three, or more traces between pin pads. To set the channel and spacing, you specify only the component pad size. The program can bend traces in channels; it doesn't violate layer-direction preference rules. Before it places any traces, the router explores all routes, analyzes all channels, and determines the best via locations. $25,000 for Scicards package.

Scientific Calculations Inc, 7635 Main St, Fishers, NY 14453. Phone (716) 385-6790. TWX 510-254-8546.

Circle No 358



WIRE-WRAP SYSTEM

The PDS 2400 automatic wire-wrapping system accepts FutureNet schematics. With a wrapping speed of 300 wraps/hour, the system features daisy-chaining and automatic error detection and correction. The system can handle several boards concurrently. An RS-232C serial port lets you interface computers to the system. To use Convert, the FutureNet translation package, you identify the components that you want to use and specify the positions of those components. This system accommodates 30- and 26-gauge wire. PDS 2400, $39,950; Convert, $950.

Mind to Matter Robotics Corp, 2810 de Miniac, Montreal, Quebec, Canada H4S 1K9.

Circle No 359

68020 WORKSTATIONS

The Sun-3/50M desktop workstation and the -3/52M stand-alone system both operate under Unix. The -3/50M is a diskless node that inter-

faces to a computer network. Evaluating 1.5 MIPS, the desktop unit combines a 15-MHz MC68020 µP, 4M bytes of memory, and a built-in Ethernet transceiver on one board. It uses the same 19-in. display that the company's other workstations include. Bundled with the system are the Suncore and SunCGI graphics libraries; C, Pascal, and Fortran compilers; and Unix system utilities. The -3/52M combines the features of the -3/50M and a 71M-byte disk drive and a 60M-byte, ¼-in. streaming-tape drive. -3/50M, $7900; -3/52M, $13,900. Delivery, 60 days ARO.

Sun Microsystems Inc, 2250 Garcia Ave, Mountain View, CA 94043. Phone (415) 960-7533.

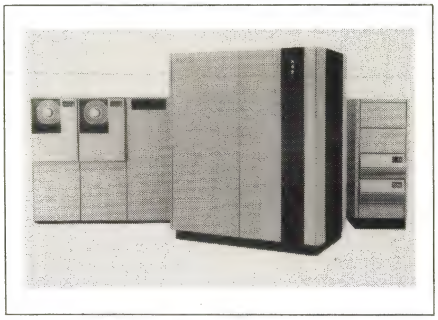
Circle No 360

AUTOMATIC ROUTER

Based on the 68020 µP, the CDX-75000 Route Engine-Plus has a memory subsystem, which contains a 32-bit data path to dual-ported RAM and a memory-address capacity to 16M bytes. The expanded memory capacity of this version accommodates the routing of boards that contain 700 or more equivalent ICs. This router uses a multilayer routing algorithm, which has been implemented in microcode and thus accelerates the performance of the routing technique. Because the router evaluates all layers simultaneously, it can rapidly find an optimum trace path for making the connection. Fewer vias are necessary, and traces are shorter than those generated by layer-pair routers. $77,000.

Cadnetix Corp, 5757 Central Ave, Boulder, CO 80301. Phone (303) 444-8075.

Circle No 361



PARALLEL PROCESSOR

This expanded version of the System 6400 is a 12-processor computer that performs 72 Whetstone MIPS.

Designed for such applications as VLSI chip design, it features a parallel-processing architecture, which offers modular expansion. Because the system uses ECL and LSI gate arrays, it can package a single 6-MIPS CPU on three circuit boards. The system provides as much as 4G bytes of virtual addressing space per process. You can expand the central computer memory to 192M bytes. The system bus, Gigabus, is a synchronous, 64-bit-wide channel that specs a system bandwidth of 320M bytes/sec. The system incorporates three operating systems: EMBOS, this company's proprietary operating system; Unix BSD 4.3; and Unix system V. The computer can compile Fortran, Pascal, Cobol, and Mainsail programs. $3,000,000.

Elxsi, 2334 Lundy Pl, San Jose, CA 95131. Phone (408) 942-0900. TLX 172320.

Circle No 522

PC-BOARD ANALYSIS

The Printed Circuit Board Analysis Program runs on any IBM-compatible MS-DOS system. The program estimates the board requirements, costs, and manufacturing parameters of pc boards. It includes file utilities for printing, storage, and retrieval from hard disk. The program will report IC equivalency, density, and feasibility of the design, and specifically define the level of difficulty using 2-, 4-, 6-, 8-, or 10-layer boards. Job-cost estimates and models can be reviewed. $99.

Animat/USA, 200 Brown Rd, Suite 300, Fremont, CA 94539. Phone (415) 659-0105.

Circle No 523

TAPE EMULATOR

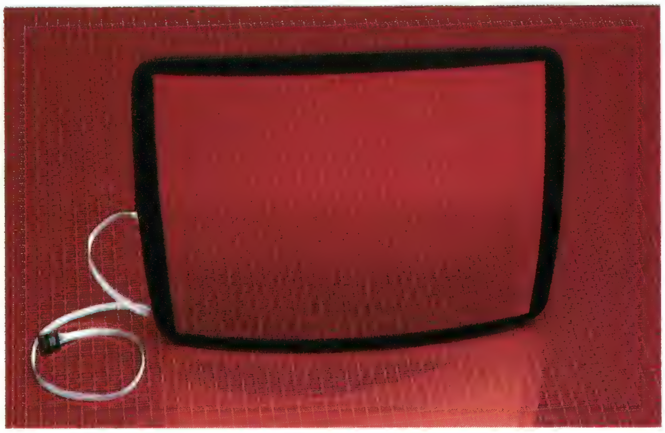
Disk-A-Tape, a punched-tape emulator, is available in a ruggedized 5¼-in. disk version and a 3½-in. protected rigid-disk configuration. Both versions feature a positive airflow filtration system that prevents contamination from foreign matter. The tape emulator replaces both paper-tape readers and punchers. You can attach the tape emulator to numerically controlled machines without adding any hardware. The 5¼-in. disks can store as much data as 3000 ft of punched tape; the 3½-in. version stores as much as 6000 ft. The emulator reads and punches data at 1500 cps when operating as a parallel reader or puncher. Both versions fit on 19-in. instrument racks and include parallel and RS-232C ports. 5¼-in. version, $2995; 3½-in. version, $3095.

Wire Graphics Inc, 95 Sherwood Ave, Farmingdale, NY 11735. Phone (516) 293-1525.

Circle No 524

Give Your Computer System the Right Touch

With the Elographics E274 Touch Screen



Your customers are looking for improved human-computer interfaces. With the E274 Touch Screen, your computer system will offer just that. And people will want to use it again and again.

Why? Because the E274 is a natural operator-computer interface. It responds to your finger's slight pressure exactly the way you expect. Without delayed, premature, or accidental triggering. With any pointing device you choose — finger, gloved finger, ball-point pen, or stylus.

And you won't need to redesign your system. Elographics has touch screens to fit most CRT's from 5 to 25" diagonal and makes custom shapes and sizes. Both RS232 and PC bus controllers are available.

To find out more about the E274 and its million-touch durability, harsh-environment reliability, and .003" resolution, get in touch with us.

We'll give your computer system the right touch.

ELOGRAPHICS

105 Randolph Road   Oak Ridge, Tennessee 37830   Telephone: (615)482-4100

CIRCLE NO 155

 CIRCLE NO 172

TERMINAL

The Model 1222 display terminal features windowing capabilities and a variety of terminal emulations. One windowing function lets you store data in two small windows; another function indicates the arrival of electronic-mail messages. You can also store more than 1000 characters in any of the terminal's four windows. The unit has a key lock for security; for even greater protection, you can use an optional software-based password to prevent unauthorized access to programs. You can specify either coaxial-cable or twisted-pair wire connections. The Model 1222 provides asynchronous communications through optional terminal emulations, including DEC VT 100, HP 2624B, Hazeltine 1510, and Televideo 950. Keyboard is included. $2866.

Lee Data Corp, 7075 Flying Cloud Dr, Minneapolis, MN 55344. Phone (612) 828-0300.

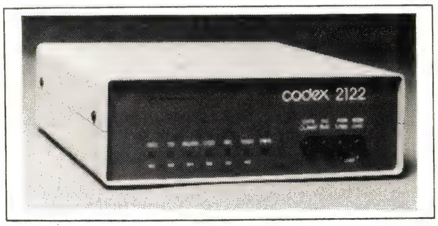
Circle No 362

INK-JET PRINTER

The JX-720 color ink-jet printer uses four ink cartridges to produce as many as 256 color combinations. An automatic printhead cleaning station minimizes nozzle clogging. The design of the ink reservoirs prevents you from splashing ink when you refill them. The printer uses 8½×11-in. cut sheets, overhead-projector transparencies, or roll paper. The JX-720 prints text at 35 cps and fills a 1024×1024-dot color-image page in 2.2 minutes with a 120-dots/in. resolution. You can connect the printer to your computer via a Centronics parallel interface. $1495.

Sharp Electronics Corp, Systems Div, 10 Sharp Plaza, Paramus, NJ 07652. Phone (201) 599-3856.

Circle No 363



NETWORK CONTROLLER

The Model 2122 features data-transmission speeds that reach 56k bps

for distances ranging as far as 7.5 mi. The 2122 supports 4-wire networks in both full- and half-duplex communications, as well as 2-wire, half-duplex networks. You can select synchronous operating speeds of 40k, 48k, 56k, and 64k bps. To ensure accurate data transmission, an automatic equalizer compensates for circuit distortion. The unit also features remote and local diagnostics and can generate internal test patterns. It is available in a stand-alone and a card version. $875.

Codex Corp, 20 Cabot Blvd, Mansfield, MA 02048. Phone (617) 364-2000.

Circle No 364

IMAGE PROCESSOR

The Imag 100 real-time image-processing workstation includes an IBM PC, a video camera, an RGB monitor, a mouse, a digital frame grabber, and software. With these components, you can perform more than 40 interactive image-processing and -analysis functions. By using the mouse and menu commands, you

HANDHELD COMPUTER

Weighing less than 2 lbs, the HP-94 handheld industrial computer features an 80C88 µP that supports programming in Basic and assembly language. Its 4-line×20-character LCD lets you monitor the computer's operation. The ruggedized unit runs on batteries. Its built-in RS-232C interface lets you communicate with a host computer. The unit also supports bar-code wands for data entry. The standard model comes with 64k bytes of RAM, expandable to 256k bytes; you can also add ROM and EPROM to a maximum of 128k bytes. An optional electroluminescent display lets you use the HP-94 in the dark. $1295.

Hewlett-Packard Co, 1020 NE Circle Blvd, Corvallis, OR 97330. Phone local office.

Circle No 365

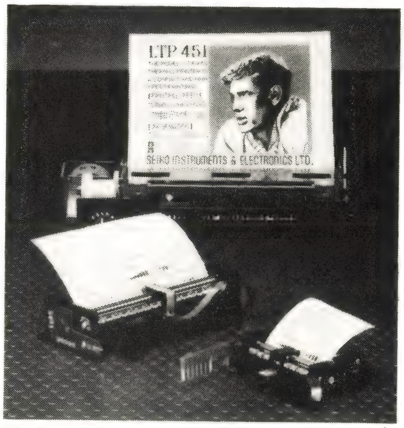
can capture a video signal at the rate of 30 frames per sec and store the image in the computer's 512×512×8-bit frame memory while simultaneously displaying the stored image on the system monitor. An optional pseudocolor module allows you to transform the monochrome input into a colored display for increased image analysis. Or you can order a full-color system with three frame-grabbing modules and an RGB camera to produce 24 bits per pixel of RGB data. $10,499.

SSE Products Inc, 791 Meacham Ave, Elmont, NY 11003. Phone (516) 872-9001. TWX 510-223-0417.

Circle No 366

THERMAL PRINTER

The LTP451 produces 7×5-dot matrix characters in 42 columns at the rate of 210 cps. Using a thermal printhead, it prints both alphanumeric and graphics characters. The



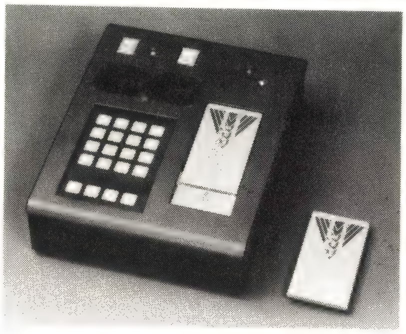
device measures 6.1×2.2×1.1 in., weighs 12 oz, and requires a 5V dc and a 24V dc power source. The unit operates from 0 to 50°C. Print resolution is 76 dots/in. It uses 4.4-in. heat-sensitive paper, covering a print width of 3.5-in. per line. $83 (1000).

Seiko Instruments USA Inc, 2990 W Lomita Blvd, Torrance, CA 90505. Phone (213) 530-8777.

Circle No 367

MEMORY CARDS

You can use the LSI Card with an LSI Card Reader for access-control applications, computer timesharing, and programmable control. Incorporating four nonvolatile memory coils in a device that is about the size of a credit card, each card has read/write memory embedded in a



plastic resin and hermetically sealed to exclude dirt, moisture, and oil. Each card comes with either 64k bytes or 256k bytes of CMOS static RAM and a lithium battery. The

Just when you thought all connectors were alike . . .

There's Welcon®!

Just when all connectors begin to look the same, cost the same, and perform the same, Welcon adds a difference.

Welcon combines the service and responsiveness of a small company with the product performance and technology of a major manufacturer.

The result is obvious when you choose Welcon connectors. You get more than a part. You get a partnership. Fast delivery, comprehensive service—the attention you get only from a company that cares.

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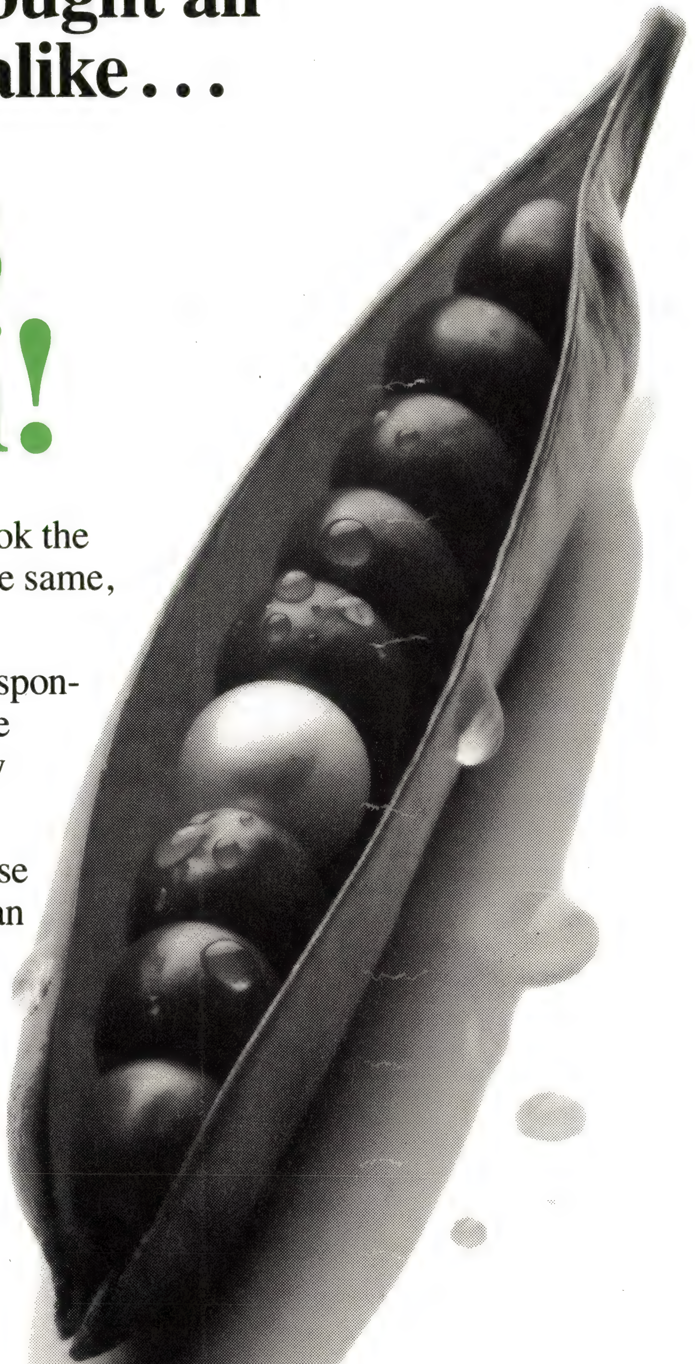


- Card Edge Connectors
- D-Sub Connectors
- Pin Headers • Shunts
- DIP Production Sockets
- Leadless Chip Carrier Sockets
- ZIF Sockets
- Burn-In/Test Sockets
- Contactors • Carriers

WELLS ELECTRONICS, INC.
1701 SOUTH MAIN STREET
SOUTH BEND, IN 46613. U.S.A.
219-287-5941 TELEX 25-8325
FAX 219-287-0356

CIRCLE NO 159

Card Reader has RS-232C, current-loop, and parallel outputs for computer interfacing. Card Reader, $1000; Card, $15 (OEM qty).

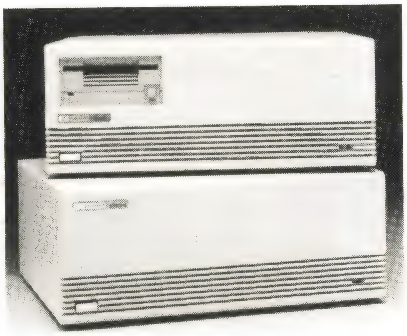
Orientation Inc, 101 Coolidge St, Hudson, MA 01749. Phone (617) 568-0509.

Circle No 368

crystal-controlled data rates. Or you can drive the unit externally from a terminal or computer. Diagnostic features include front-panel indicators and a digital loop-back switch. $475.

Electrodata Inc, 23020 Miles Rd, Bedford Heights, OH 44128. Phone (216) 663-3333. TWX 810-427-2280.

Circle No 370



HARD-DISK DRIVES

The 9133L is a 40M-byte hard-disk drive in a stand-alone cabinet. The 9134L is similar to the 9133L but also includes a 3½-in. floppy-disk drive in its cabinet. Both drives feature a 40-msec access time and allow you to partition the hard disk into as many as eight volumes. (This latter feature is particularly useful for storing multiple operating systems on one drive.) Among the computers that accept these drives are the manufacturer's 9000 workstations, its Models 250 and 260 computers, the Touchscreen II, and the IBM PC family. 9133L, $4450; 9134L, $4050.

Hewlett-Packard Co, 3000 Hanover St, Palo Alto, CA 94304. Phone local office.

Circle No 369

INTERFACE CONVERTER

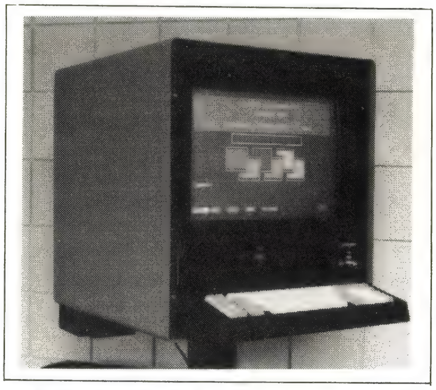
Supporting the RS-232C and CCITT V.35 interfaces, the ME 3 allows you to directly connect two terminals or computers without using modems. The device provides interface conversion for data communication at speeds ranging from 14.4k to 896k bps. You can set the unit's internal clock to any of 19

MULTIUSER TERMINAL

You can use PCTerm, a multiuser terminal, with your IBM PC or compatible computer. Its 14-in. green or amber CRT displays a 256-character set in the IBM PC-style font. It supports 80- and 132-column displays, and its keyboard resembles that of an IBM PC/AT. The terminal has two bidirectional RS-232C ports: You can simultaneously connect one port to an IBM PC and the other to another host computer. In addition to its native IBM PC mode, the terminal emulates a WY-50 and a TeleVideo 925. $649.

Link Technologies Inc, 2260 Paragon Dr, San Jose, CA 95131. Phone (800) 223-8626; in CA, (408) 943-0143. TWX 910-338-2143.

Circle No 371



INDUSTRIAL COMPUTER

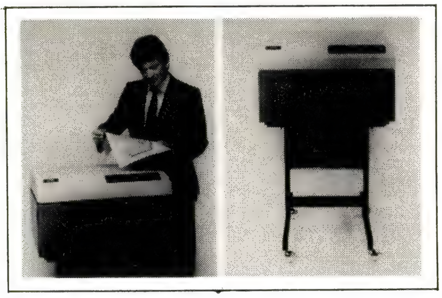
The Expert computer, designed for use in a factory environment, is enclosed in a ruggedized NEMA 12 enclosure. It features a thermostatically controlled dynamic heat exchanger for use in high-temperature locations. The unit has a membrane keyboard, an 80286 CPU, 640k bytes of RAM, eight I-Bus expansion slots, and a 19-in. color CRT. You can order an 8088 μP as an option. $1995.

Comark Corp, Box 474, Medfield, MA 02052. Phone (617) 359-8161. TLX 703156.

Circle No 372

COLOR PLOTTER

The Spectrum can serve either as an electrostatic color plotter or as a line printer. It produces both A-size (8.5×11-in.) and B-size (11×17-in.) drawings. When used with an optional video interface, it produces hard copy directly from a CRT image. The machine uses either paper or polyester film; print speed is 2 ips with a 200-dot/in. resolution. Using this plotter, you can produce



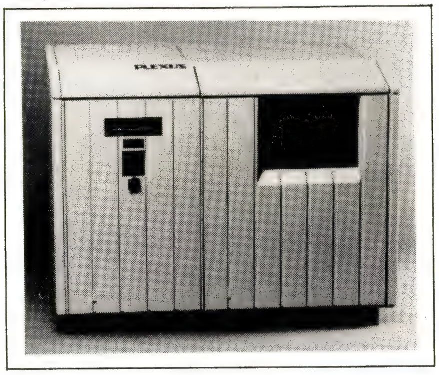
an A-size monochrome drawing in 5 sec or color drawing in 60 sec. A B-size monochrome plot takes 10 sec and a color version <90 sec. This unit also emulates the manufacturer's V-80 printer/plotter in monochrome mode, printing text with 132 cpl at 1000 lpm. A built-in raster-data translator converts 100-dots/in. data to 200-dots/in. density; the translator thus lets the host computer generate less data and thereby plot faster. $11,950.

Versatec, 2710 Walsh Ave, Santa Clara, CA 95051. Phone (800) 538-6477; in CA, (800) 341-6060.

Circle No 373

UNIX COMPUTER

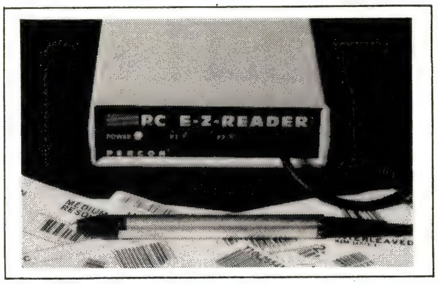
Based on a 68020 μP, the P/75 computer supports as many as 80 terminals with its Unix-based operating system. You can configure the system with as much as 16M bytes of RAM and 6.5G bytes of disk storage. The system also uses dedicated



communication processors that relieve the CPU of I/O functions. Each communication-processor board includes a 35-channel DMA processor and a 2M-byte buffer memory. Standard features include a 15-slot card cage, 1M byte of error-correcting RAM, a 60M-byte cartridge tape drive, a mass-storage processor, and a 145M-byte, 8-in. Winchester drive. The system also comes with a built-in 110-, 300-, and 1200-baud autodial, autoanswer modem. From $36,000.

Plexus Computers Inc, 3833 N First St, San Jose, CA 95134. Phone (408) 943-9433. TWX 910-338-2223.

Circle No 374



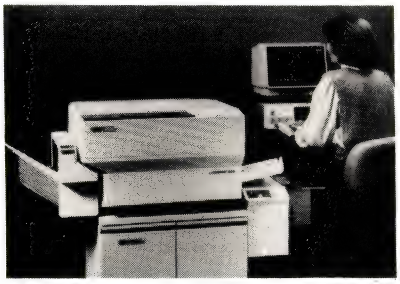
BAR-CODE READER

The EZ Reader provides automatic recognition and decoding. This bar-

code reader interprets several formats, including Code 39, UPC A/E, Codabar, Codabar/ABC, and Interleaved 2 of 5. The wand uses a decoding algorithm that incorporates error-checking routines to ensure accurate decoding for both dot-matrix and preprinted labels. The scanner comes with either an RS-232C interface or an IBM PC/XT keyboard interface. The keyboard-interface model requires no software modifications and permits full use of the keyboard at all times. You can also order optional IBM PC/AT and Tektronix 4100 keyboard interfaces. From $635.

Percon Connections Inc, 2190 W 11th St, Eugene, OR 97402. Phone (503) 344-1189.

Circle No 375

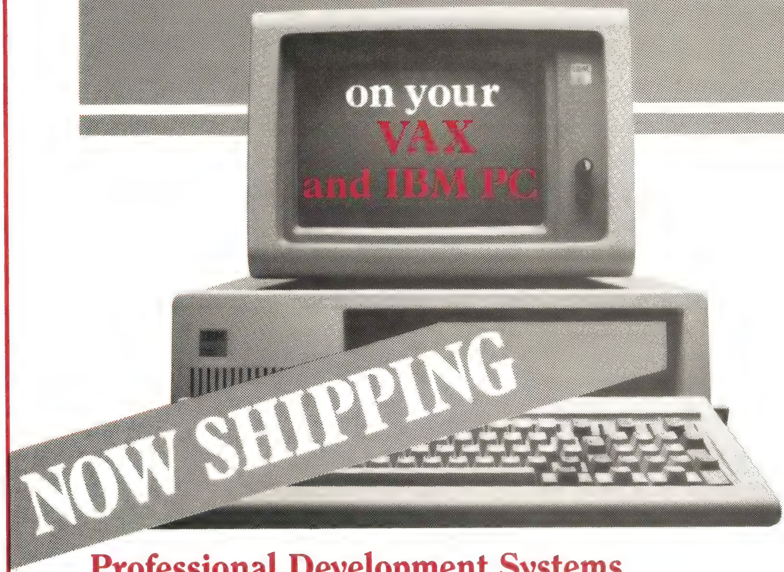


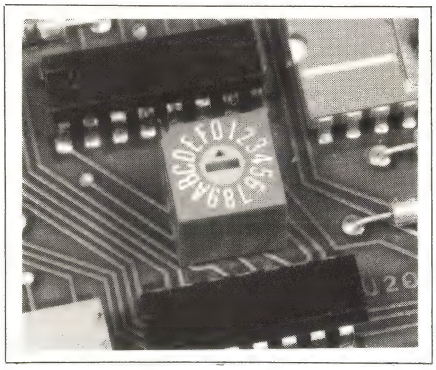
LASER PRINTER

The Laserprint 2670 produces letter-quality documents at speeds reaching 1500 lpm. You can use this printer to emulate a plotter, or a line or daisy-wheel printer. Its 300-dots/in. resolution lets you create bar codes and bit-mapped graphics. You can specify a plug that's compatible with IBM, DEC, or Wang computers. You can load this printer with 2000 pages for continuous production workloads. Its dual input cut-sheet feeder accepts paper as large as 11×17 in. The manufacturer estimates a cost per page of $0.018. $11,400.

Advanced Technologies International Inc, 2041 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 748-1688.

Circle No 376





DIP SWITCHES

The Series 74 16-position hexadecimal and 10-position BCD rotary DIP switches provide direct input to logic circuitry without a coding interface. The switches provide single-setting accuracy and measure 0.38×0.38×0.295 in. Terminals are located on DIP centers with a common lead on each side. Common leads are internally connected. A standard epoxy-sealed base protects the bottoms of the switches during board assembly and cleaning processes. For a complete seal, a factory-applied top-tape seal is available as an option. $3.28 (100).

Grayhill Inc, Box 10373, La-Grange, IL 60525. Phone (312) 354-1040. TWX 970-683-1850.

Circle No 377

CRYSTAL OSCILLATORS

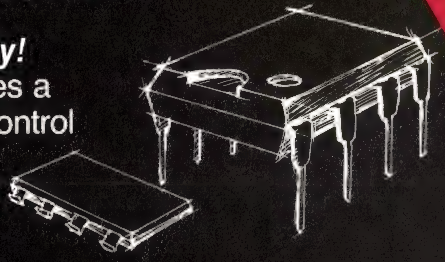
The Models KTXO and KTVXO temperature-compensated crystal oscillators are compatible with 14-pin DIP ICs and TTL and CMOS circuits. The KTXO has a frequency range of 4 to 50 MHz; the KTVXO has a frequency range of 10 to 20 MHz. You can obtain a fine frequency adjustment with 1 to 5V on pin 1. Modulation sensitivity for the KTVXO is 10 ppm/V min. Both oscillators are available in the temperature range of −20 to +70°C with an aging rate of 1 ppm/year. Frequency tolerance is 3 ppm. From $15 (1000). Delivery, six to eight weeks ARO.

Kyocera International Inc, Electronic Components Group, 11425 Sorrento Valley Rd, San Diego, CA 92121. Phone (619) 454-1800.

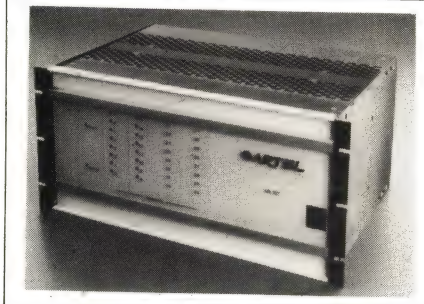
Circle No 378

MULTIPLEXER

The MX327 multiplexes as many as 32 channels of the IBM 3272's I/O on



one optical or coaxial cable. It connects a 3272 controller to 3270 terminals and 3280 printers as far away as 5000 ft. The multiplexer accepts the inputs and multiplexes them into a signal that is then converted into light (for fiber-optic cable) or electrical pulses (for coaxial cable). At the far end, the signal is demultiplexed by a second MX327 into its



original form. The 19-in. rack-mounted unit is designed for synchronous applications at data rates to 2.3587M bps. Each modular unit contains four cards; additional cards can be added to reach the 32-channel capability. The multiplexer features diagnostic indicators on the front. It is plug compatible with standard BNC connectors for data-transmission and SMA-type connectors for optical transmission. Two 32-channel units, $7600.

Artel Communications Corp, Box 100, West Side Station, Worcester, MA 01602. Phone (617) 752-5690.

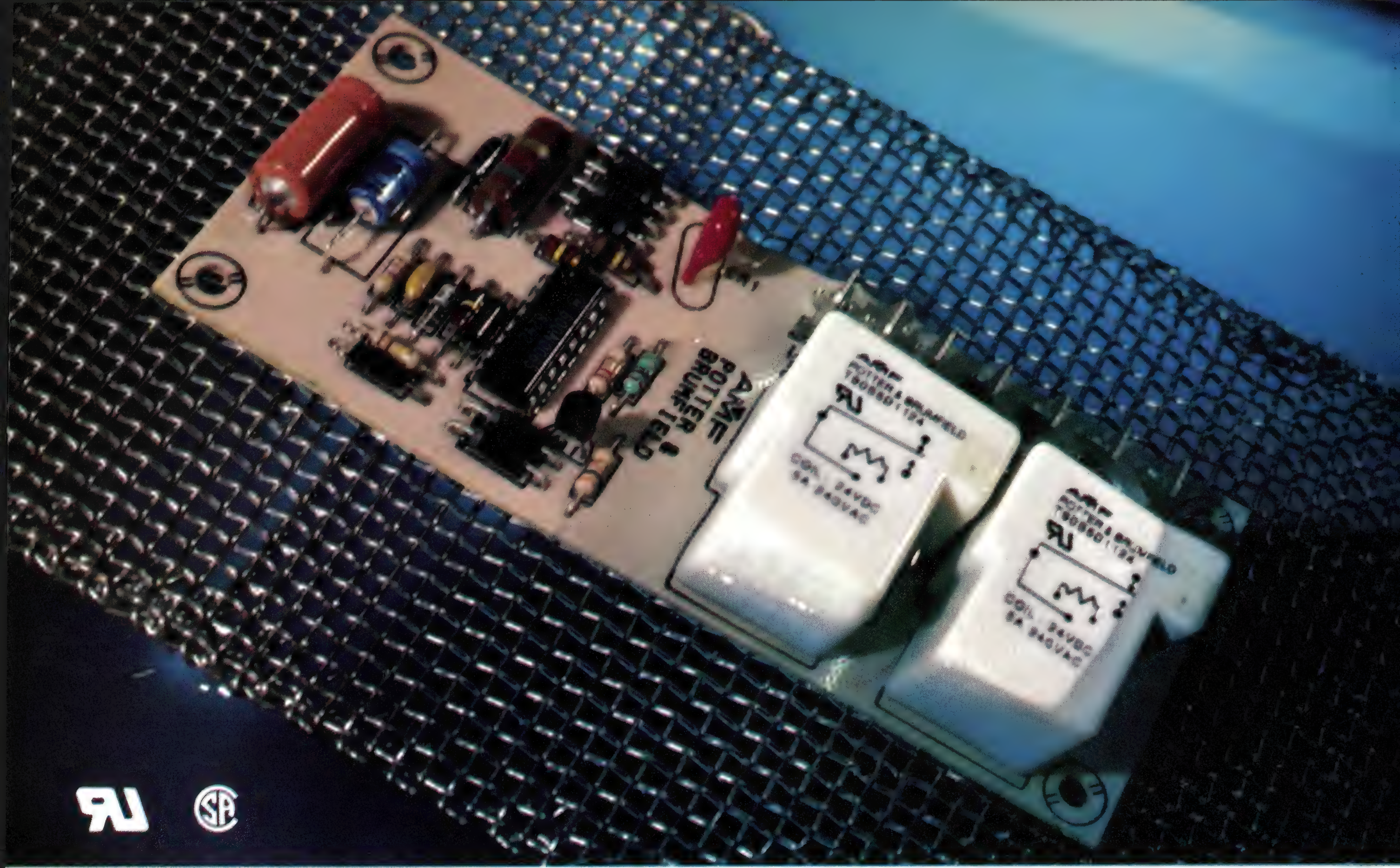
Circle No 379

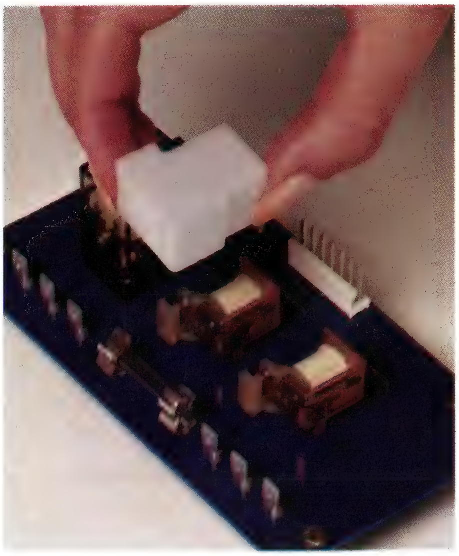
FLAT CABLE

The AC Series gray flat cable and CSK Series multicolored cable are both available in 100-ft reels. The AC line spans 10 to 64 conductors, and the CSK covers 9 to 64 conductors, all on 0.05-in. center spacings. Wire gauge is 28 AWG, and maximum operating rating equals 105°C. Both series accommodate currents of 1A. Voltage rating equals 300 and 250V for the AC and CSK cables, respectively. 26-conductor AC, $17.63; 26-conductor CSK cable, $33.97. Delivery, stock to six weeks ARO.

Amlan Inc, 97 Thornwood Rd, Stamford, CT 06903. Phone (203) 322-1913.

Circle No 380





LED DISPLAYS

With high-efficiency red characters measuring 1.05 in. high, HDSP-4500 displays are readable at distances to 60 ft. The displays feature a 5×7 dot-matrix font and are available in common-anode-row and common-cathode-row models. The units are housed in DIPs to facilitate mounting on pc boards. The displays can be stacked end to end, or side by side to satisfy graphics panel applications. Luminous intensity (for 10-mA drive) equals 3.5 mcd/dot. $6.65 (1000).

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 381

MULTIPLEXER

The CDS-372 general-purpose, fiber-optic multiplexer is compatible with Datakit, AT&T's virtual circuit switch. The CDS-372 is available with 36 or 72 channels, each channel with one data and one control line. It handles asynchronous data at rates to 100k bps and synchronous data to 76.8k bps. The basic 36-channel model can be expanded to the 72-channel model. The unit features mass-terminated 50-pin connectors with each connector handling six RS-232C channels. The unit includes diagnostic capabilities to determine synchronization and local and remote loopback functions. Features also include a choice of stand-alone or rack-mounted versions, full-duplex operation, bit-error rate of 1×10^{-9} or better, and code transparency. From $3950.

Canoga-Perkins, 6635 Independence Ave, Canoga Park, CA 91303. Phone (818) 887-1897.

Circle No 382

PANEL METER

Mini Versameters feature a low-profile package to save panel space. They are available in voltage and current models. Decimal points are

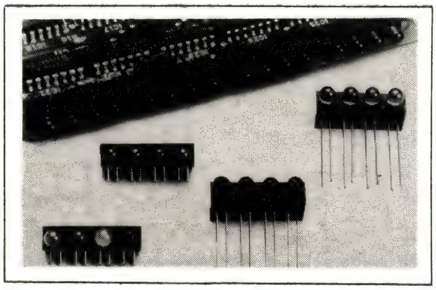
selectable via rear-panel connections. The voltage and current models accept inputs from 200 mV to 100V dc and 200 μA to 2A, respectively. Model G922DA allows users to program and display a 4- to 20-mA process signal generated by a transducer. All meters feature a 0.5-in.-high, 3½-digit LED display. From $69.

Extech Instruments Corp, 150 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-7440.

Circle No 383

LED ARRAYS

The PCL1904/2004 Series quad LED arrays offer a choice of four colors—red, yellow, amber, or green. The units feature T-1¾-size LEDs and are available in either standard-bright, medium-bright, high-efficiency or super-bright versions. Bicolor versions are also available. Offering good alignment



and matched color, these arrays come in mitered packages with horizontally mounted LEDs. $0.74 (1000). Delivery, four to six weeks ARO.

Data Display Products, 301 Coral Circle, El Segundo, CA 90245. Phone (800) 421-6815; in CA, (213) 640-0442.

Circle No 384

PADDLE SWITCH

The Tiny Paddle Switch is designed for panel mounting. The actuator is available in red, black, white, blue, and custom colors, all with matte finish. The switch mounts in a ¼-in. hole that allows simple retrofitting, and it features wire-lug, pc-board, or wire-wrap terminals. Contact ratings are 3A at 125V ac or 28V dc, or 0.4 VA at 20V ac or dc. The on-on model has a life expectancy of 80,000 cycles at full load. You can choose either silver or gold contacts. A typical on-on wire-lug ver-

sion costs approximately $3 (2500). Delivery, six weeks ARO.

Alco Electronic Products Inc, 1551 Osgood St, North Andover, MA 01845. Phone (617) 685-4371. TWX 710-342-0552.

Circle No 385

Activate Your System –

with PEP™ – the Touch Entry Panel

Make your system easy-to-use with the touch-activated PEP™ from IEE. **Training costs and input errors are reduced** when the operator can concentrate on the task at hand, not on complicated protocol.

PEP **goes where a CRT can't**—it's less than 3.4 inches (87mm) deep.

PEP is available in **two sizes**—a compact 12×40 character format (480 PEP) and a larger-character 8×32 (256 PEP). Both come in a choice of display colors—Orange, Green or Red.

Four **standard interface** modes make communication a snap—choose RS-232-C, 20mA current loop, RS-422-A, or parallel data bus.

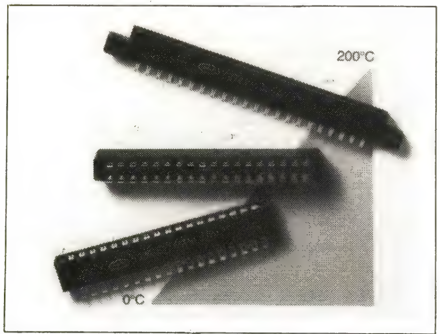
IEE has a special **evaluation kit offer** so you can see how a PEP will look and work in your system. Call or write us today!

Circle 7 for Immediate Application

IEE

Industrial Products Division
Industrial Electronic Engineers, Inc.
7740 Lemona Ave., Van Nuys, CA 91405
Tel. (818) 787-0311 - Ext. 418
FAX: (818) 902-3723

Circle 46 for Reference Material



CONNECTORS

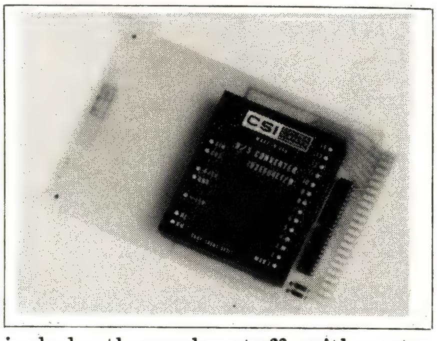
A high-temperature thermoset-molding compound used for the connector body and beryllium copper used for the contacts allow the EB7D and EB8 Series edgeboard connectors to withstand operating temperatures of 200°C. The connectors feature 0.156-in. center-to-center spacings on 0.140- and 0.200-in. grids, respectively. Selective gold plating of the contacts is standard. The devices are available with a variety of terminals including dip-solder, solder-eyelet, and card-extender styles. You can order the EB7D with six, 10, 12, 15, 22, 36, or 43 contacts per side; the EB8 has a choice of six, 10, 12, 15, 18, 22, 24, or 25 contacts per side. Approximately \$4.80 (1000) for an EB8 with two rows of 22 or 44 contact positions and card-extender terminals. Delivery, four to six weeks ARO.

Dale Electronics Inc, Box 609, Columbus, NE 68601. Phone (605) 665-9301.

Circle No 386

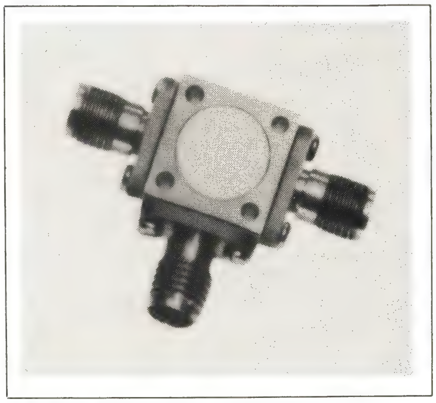
D/S CONVERTERS

The SCB-22 Series of card-mounted digital-to-synchro (resolver) converters provide 1.5 or 5W of output power to drive size 11 torque receivers or control transformer loads for simulator or trainer applications. All outputs are short-circuit and overload protected; the 5W units include thermal cutoff with automatic recovery from locked-rotor conditions. Standard transformer-isolated outputs are 11.8 or 90V line-to-line with 26 or 115V rms reference at 400 Hz. Twelve- or 14-bit digital inputs are stored in a set of TTL-compatible latches. The cards measure 4.24×6.25 in. From \$470. Delivery, four to six weeks ARO.



Control Sciences Inc, 9509 Vassar Ave, Chatsworth, CA 91311. Phone (818) 709-5510.

Circle No 387



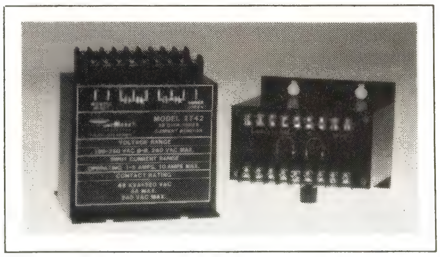
MINIATURE MIXER

Housed in a 0.5×0.5×0.2-in. package, the Model DCM4-26 mixer features ground tabs that facilitate soldering to both coplanar and microstrip ground planes. The mixer was designed to meet small-size requirements for wideband electronic-counter-measure mixers and to provide shielding and low VSWR connections. Removable SMA connectors are provided for testing prior to solder-in installation. Typical specifications in the 4- to 26-GHz band include RF range of 4 to 26 GHz, local-oscillator (LO) range of 4 to 26 GHz, IF range of 1 to 10 GHz (−1 dB), and LO injection of 10 to 13 dBm. Typical conversion loss is 9 dB from 2 to 18 GHz and 10 dB from 18 to 26 GHz. $995. Delivery, 120 days ARO.

RHG Electronics Laboratory Inc, 161 E Industry Ct, Deer Park, NY 11729. Phone (516) 242-1100. TWX 510-227-6083.

Circle No 388

CURRENT SENSOR



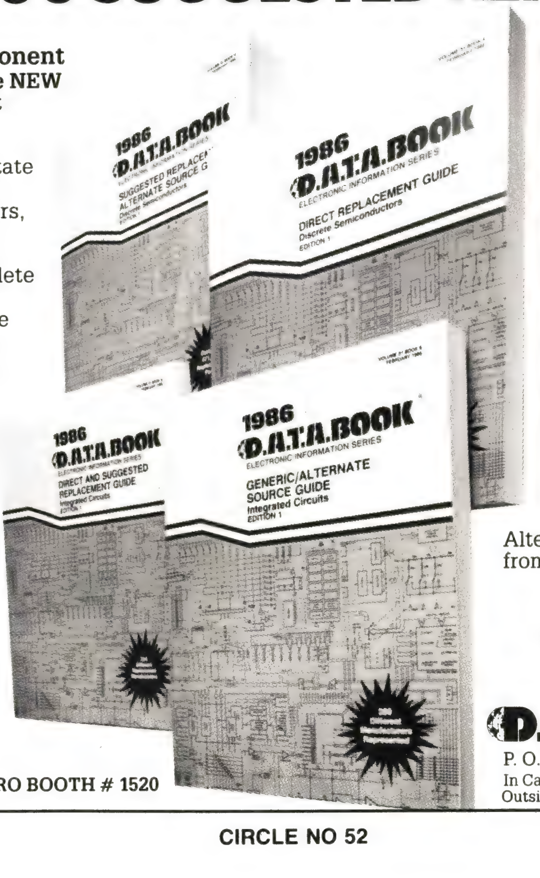
The Model 2742 current-sensing relay is designed for 3-phase applications. You can use it to monitor for undercurrent or overcurrent conditions: As shipped, the device will monitor undercurrent conditions; by adding a wire, you can adapt it to monitor overcurrent conditions. You can also add a NC pushbutton to the relay if manual reset is required. The device is housed in a high-impact ABS plastic, machine-tooled case. Versions are available for 24, 120, and 240V ac sources. The sensor can monitor to 480V ac, 5A; you can extend the range by using current transformers. $133.75.

Time Mark Corp, 11440 E Pine St, Tulsa, OK 74116. Phone (918) 438-1220.

Circle No 389

IC SOCKETS

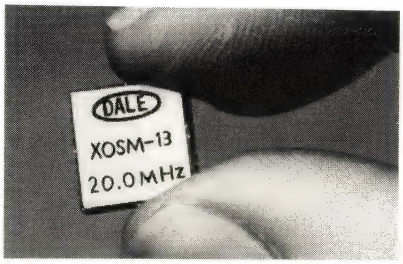
The 2300 and 2400 Series sockets accommodate 70-mil-lead spacing ICs, thereby accommodating μPs,



μCs, and video controllers from Hitachi, Mitsubishi, Fujitsu, and NEC. They have a machined sleeve, a machined inner contact, and solid- and open-ladder glass insulators. The sockets are available in 28-, 30-, 40-, 42-, 52-, and 64-pin versions. The sockets are tested to standards such as MIL-STD-1344A and MIL-STD-202. Gold-plated (30-μin.) and tin/lead-plated contact versions are available. Gold contact, $5.32; tin/lead contact, $4.48 (100).

Augat Inc, Box 779, Attleboro, MA 02703. Phone (617) 222-2202.

Circle No 391



CLOCK OSCILLATOR

The XOSM-13, a TTL-compatible clock oscillator, is available in a frequency range from 16 to 24 MHz. Frequency stability is ±100 ppm over −55 to +125°C. Supplied in a 40-pin leadless chip carrier, it occupies 0.48×0.48 in. of board space. It's hermetically sealed to meet MIL-STD-833, Method 1014 and is designed for reflow soldering. A typical 16-MHz XOSM-13, $48.26 (100).

Dale Electronics Inc, 2064 12th Ave, Columbus, NE 68601. Phone (602) 967-7874.

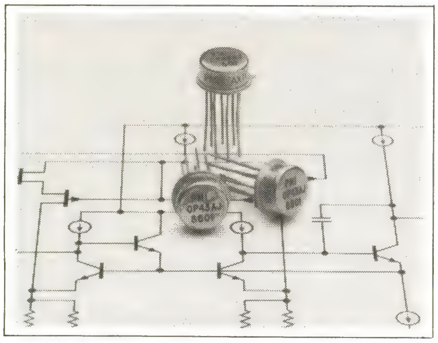
Circle No 392

OPTOCOUPLERS

A 16-pin, dual-channel, line-receiver family of optocouplers provides a guaranteed common-mode transient immunity of ±1000V/μsec. The hermetically sealed devices are available either as standard products (HCPL-1930) or with full MIL-STD-883, level B testing (HCPL-1931). Both types are specified over the full military temperature range. In line-receiver applications, an input-current regulator serves as a line termination to clamp line voltage and to regulate the LED current. The regulator also minimizes the effect of line reflections and shunts excess current (above a typical LED current of 12.5 mA). Optocouplers can accept inputs to 10M bps. Propagation delay time to both high- and low-output levels is 100 nsec max. At an input current of 10 mA, the output will sink six TTL gates. HCPL-1931, $92; HCPL-1930, $50.75 (50).

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 393

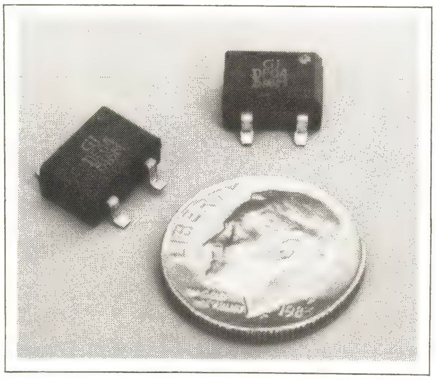


OP AMP

Offering the same dc specifications and 5-pA bias current as the OP-41, the OP-43 features a slew rate of 5V/μsec min and a gain-bandwidth product of 2.4 MHz typ. It achieves this speed while drawing a supply current of only 1 mA max. CMR is 100 dB min, and the op amp is stable with closed-loop gains of −1 or +2. A cascode input stage stablilizes bias current against changing common-mode voltages, and improves common-mode-rejection linearity. The device drives a 100-pF load without oscillation and has power-supply rejection of 92 dB min and supply-current consumption of 1 mA max. In an 8-lead, TO-99 metal can, $3.50 (100).

Precision Monolithics Inc, 1500 Space Park Dr, Santa Clara, CA 95052. Phone (408) 727-9222.

Circle No 394



BRIDGES

The DF-S Series of miniature single-phase surface-mount bridge rectifiers includes seven 1A devices that have glass-passivated junctions and a surge overload rating of 50A pk. They exceed MIL-STD-19500 environmental standards and have voltage ratings ranging from 50 to 1000V. In molded plastic cases, $0.30 (1000).

General Instrument Corp, Discrete Semiconductor Div, 600 W John St, Hicksville, NY 11802. Phone (516) 933-3333.

Circle No 395

VIDEO DACs

The NE5150/5151 triple 4-bit video DACs include composite-video functions to make output waveforms meet RS-170 and RS-343 industry standards. The NE5150 has an onboard voltage reference that provides immunity to power-supply variations. The chip has a refresh rate of 110 MHz; you can thus use it in applications having high-resolu-

Continued on page 295

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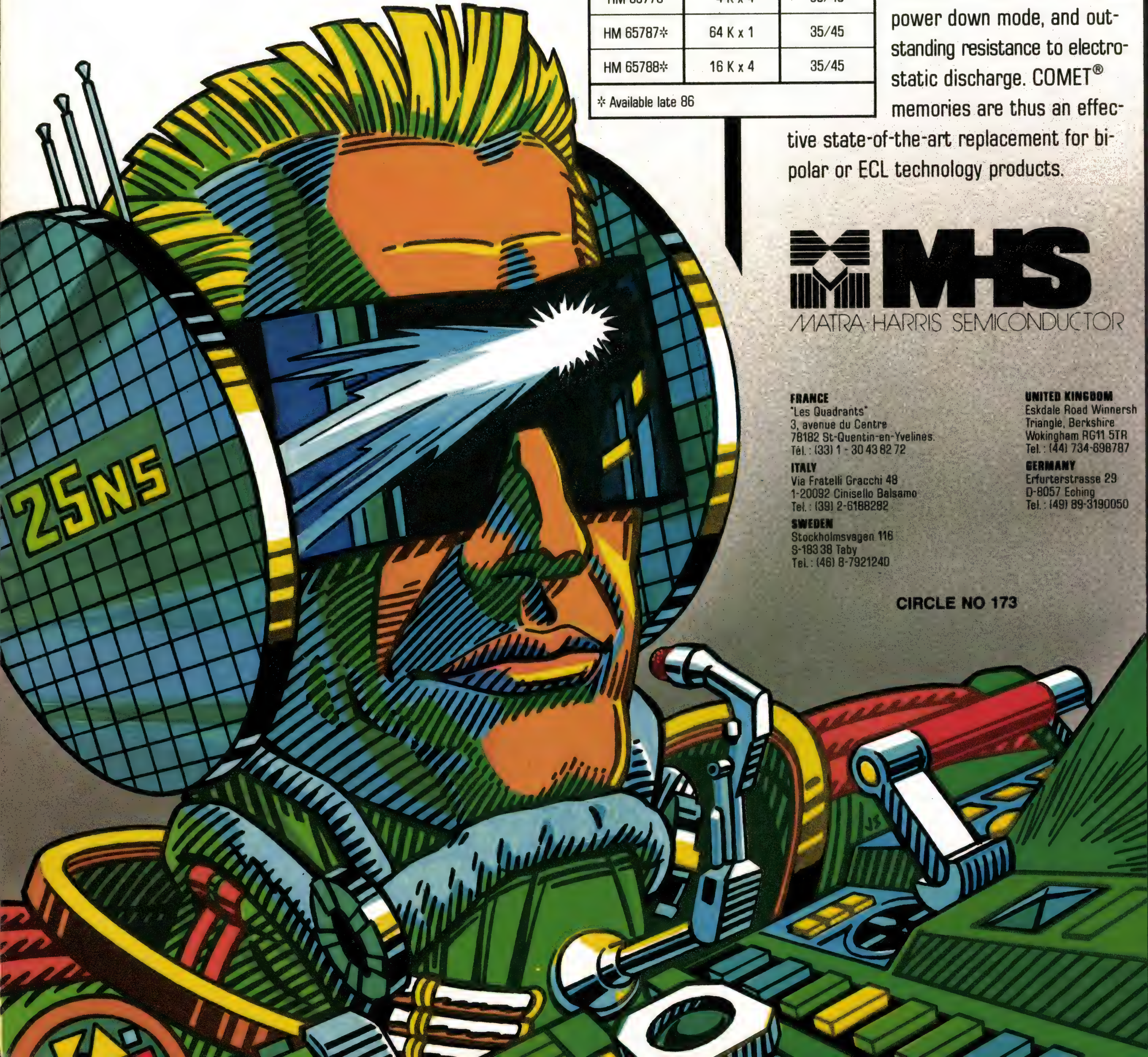
HM 65748/49	1 K x 4	25/35/45
HM 65767	16 K x 1	25/35/45
HM 65728/29	2 K x 8	35/45/55
HM 65768/69	4 K x 4	25/35/45
HM 65770	4 K x 4	35/45
HM 65787✲	64 K x 1	35/45
HM 65788✲	16 K x 4	35/45

✲ Available late 86



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Tel. : (49) 89-3190050

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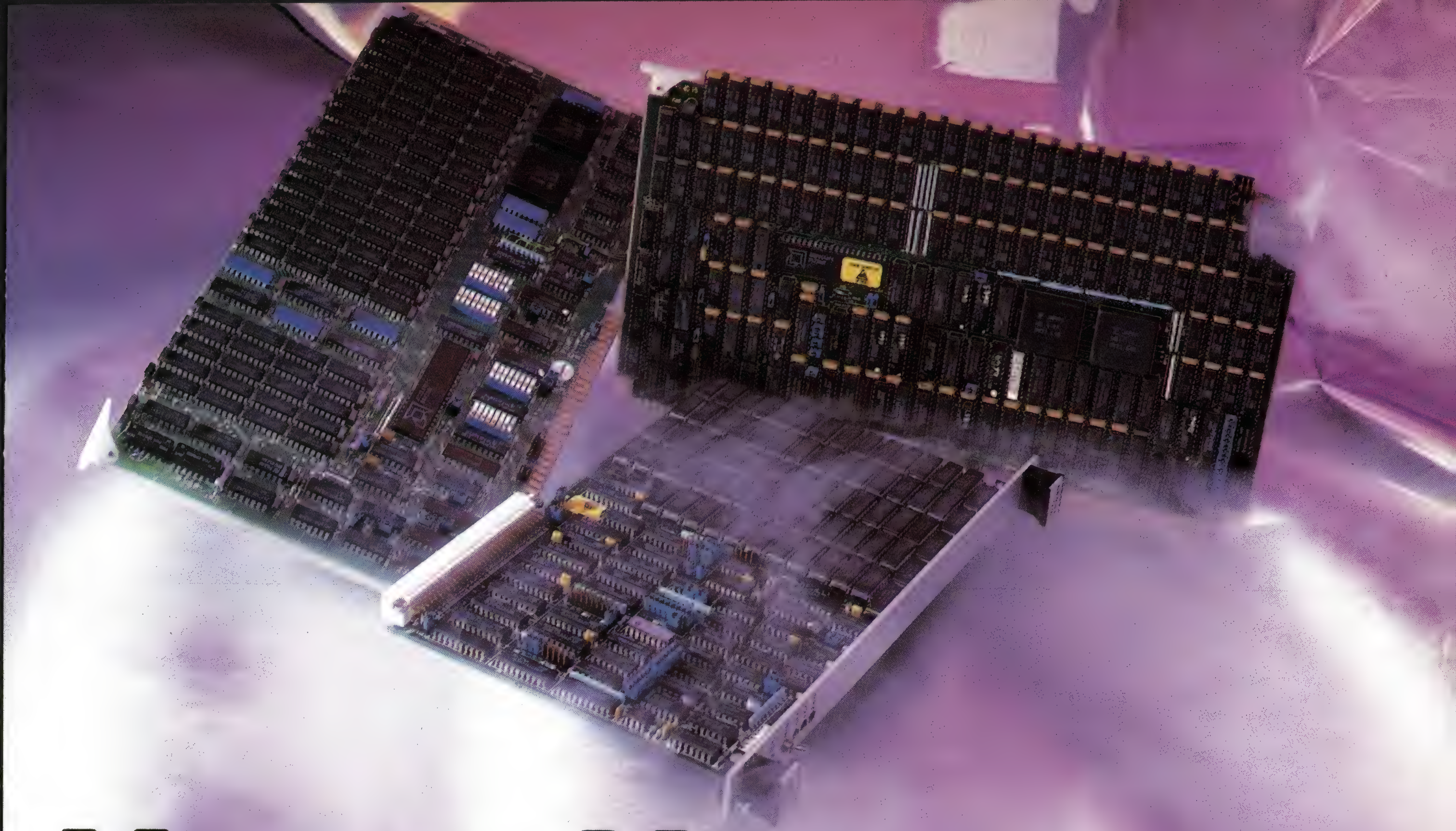

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VMEbus	4 Mbyte DRAM	•	•	8/16/32	150nS	270nS	•	•
VERSAbus†	4 Mbyte DRAM	•	•	8/16/32	300nS	300nS	•	
iLBX	2 Mbyte DRAM		•	8/16	200nS	200nS	•	
Bubble	2 Mbyte		•	—	36mS	36mS		•

*TM Intel. †TM Motorola

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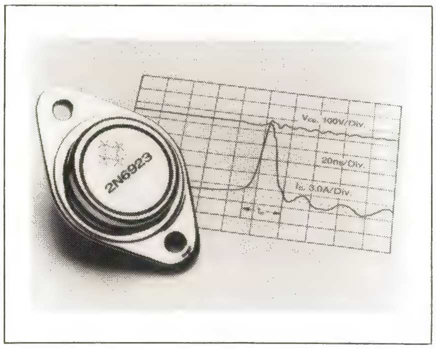
tion graphics and imaging. The device resolves 16 gray-scale levels. Also, it contains three separate ECL memory look-up tables with read/write controls—the tables consist of 16×4-bit RAMs for the red, green, and blue channels. The device contains four composite-video controls: blanking, sync, reference white, and 10% bright. On-chip registers latch these signals to prevent screen-edge distortions. All logic inputs to the chip are TTL and ECL compatible. The NE5151 has no memory look-up tables, but it can select colors from look-up tables in external-memory and access the three 4-bit DACs at update rates of 150 MHz. Both devices use ±5V supplies and operate over a 0 to 70°C range. $43 (100).

Signetics Corp, Box 3409, Sunnyvale, CA 94088. Phone (408) 991-4516.

Circle No 396



NPN TRANSISTORS

The 2N6922 and 2N6923 bipolar switching transistors, which are members of the Switch Plus III family, offer guaranteed performance specs at 100°C; they also feature 15A nominal operating currents. The 2N6922 specs a V_{CEO} of 400V; the 2N6923 has a V_{CEO} of 450V. Typical $V_{CE(sat)}$ is 0.8V at 100°C. The JEDEC-registered transistors suit 120/220V ac off-line switching applications at frequencies to 100 kHz. At 25°C, typical rise time is 32 nsec, fall time is 30 nsec, and storage time is 900 nsec. Operating and storage junction-temperature range is −65 to +200°C. The transistors' reverse-biased safe operating area permits inductive-load switching to 500V at 30A with no degradation. 2N6922, $12.60; 2N6923, $14.50 (100).

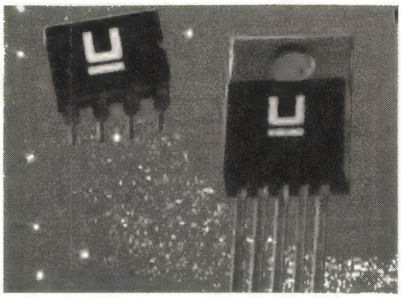
General Semiconductor Industries Inc, Box 3078, Tempe, AZ 85281. Phone (602) 968-3101. TWX 910-950-1942.

Circle No 397

SENSOR ICs

This line of ICs combines temperature monitors and heaters that allow monitoring airflow velocity past the device's package. Programming a power level to be dissipated by the internal heater will cause the die temperature to rise by an amount dependent on the thermal resistance between the die and the sur-

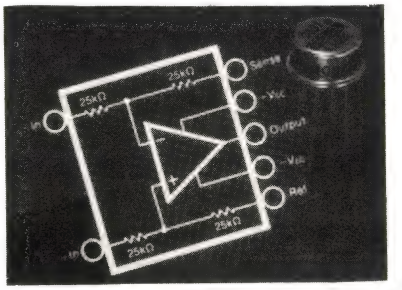
rounding air. The effective thermal resistance is strongly dependent on the velocity of any airflow passing the package. As a result, the reported die temperature varies as a function of airflow. You can set a threshold using an onboard alarm comparator that results in an alarm output either if ambient temperatures rise above a specified level, or



if airflow in the surrounding environment diminishes to a set level. The devices come in three packages and satisfy a variety of applications. The UC3730N (in an 8-pin DIP) monitors ambient temperatures. The UC3730T (in a 5-pin TO-220) monitors surface temperatures, and the UC3730W (in a 12-pin "batwing": a 16-pin outline with protruding tabs) monitors airflow in power supplies or anywhere fan cooling is critical. $1.75 (100).

Unitrode Integrated Circuits Corp, 7 Continental Blvd, Merrimack, NH 03054. Phone (603) 424-2410.

Circle No 398



DIFF AMP

The INA105 combines a premium op amp and a precision, low-drift resistor network on a single chip. Laser trimming ensures accuracy (gain error, nonlinearity, offsets, and CMR) of better than ±0.015%, thus eliminating the need for external adjustments. The device can draw 20 mA from the positive supply, thereby simplifying 4- to 20-mA current-source and transmitter designs. Other features include CMR of 86 dB min, 5-μsec settling to 0.01%, and 2-mA max quiescent current. In a metal T0-99 package, $5.75 (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111.

Circle No 399

ROMs

The LH5300 CMOS ROMs specify 30-μA standby current and maximum operating currents as low as 30 mA. The LH2300 Series is the

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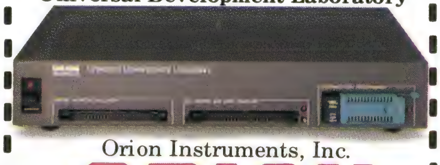


Orion Instruments, Inc.

ORION

702 Marshall Street
Redwood City, California 94063

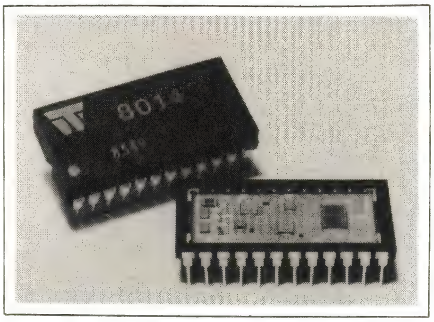
NMOS counterpart of the LH5300 devices. Both families offer densities ranging from 32k to 256k bits. For example, the LH23257 and LH53257 256k-bit (organized as 32k×8 bits) ROMs have 250-nsec max access times and are TTL compatible. Lower speed, lower power CMOS devices in the LH5300 Series offer densities from 32k to 512k bits. In JEDEC-standard, 28-pin plastic DIP, the LH23257 and LH53257 cost $4.34 and $6.18, respectively (5000). Delivery, eight weeks ARO.

Sharp Electronics Corp, Sharp Plaza, Mahwah, NJ 07430. Phone (201) 529-8757.

Circle No 400

EEPROM

The 8014 is a 16,384-bit programmable hybrid EEPROM that has a 2k×8-bit format and 3-state outputs. The device operates from −55 to +200°C. You can reprogram it at



temperatures as high as 150°C and read it at temperatures through 200°C. The EEPROM includes on-chip address latches and a separate output-enable control. At 200°C, the device offers a 250-nsec access time, an operating power-supply current of 30 mA/MHz, and a standby power-supply current of 20 mA. In a 0.600-in.-wide, 24-pin ceramic DIP, $121 (100). Delivery, eight weeks ARO.

White Technology Inc, 4246 E Wood St, Phoenix, AZ 85040. Phone (602) 437-1520. TWX 910-951-4203.

Circle No 401

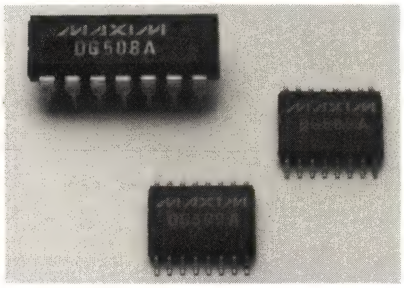
CMOS 8-BIT μP

The MSM80C85A-2 operates at 5 MHz and draws less than 20 mA from a power supply. According to the manufacturer, this device is the industry's fastest CMOS version of the 8085A-type 8-bit μP. It uses a multiplexed address/data bus. The device provides direct interface to the on-chip address latches of the MSM81C55 CMOS static RAM/timer and I/O chip and also to the MSM83C55 CMOS 2k×8-bit ROM and I/O chip. The MSM80C85A-2 operates on a 4 to 6V supply and over −40 to +85°C. Other features include full compatibility with the NMOS 8085A; a 0.8-μsec instruction cycle; an on-chip clock generator with external crystal; an on-chip controller; advance cycle-status information available for large-system control; four vectored interrupt inputs; a serial-in/serial-out port; decimal, binary, and double-precision arithmetic; and addressing capabili-

ty of as many as 64k bytes of memory. In a 40-pin DIP, $7.30 (100).

Oki Semiconductor, 650 N Mary Ave, Sunnyvale, CA 94086. Phone (408) 720-1900. TWX 910-338-0508.

Circle No 402



MULTIPLEXERS

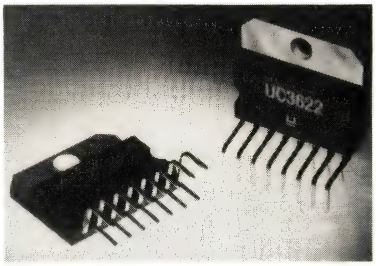
The DG508A and DG509A symmetrical analog multiplexers are 8-channel and 4-channel devices, respectively. The company guarantees these devices have break-before-make switching and that they will not latch up if the power supplies are turned off with the input signals still connected. Improved specifications, as compared with industry-standard devices, include lower positive and negative supply currents (±0.2 vs ±2.4 mA), lower drain-off and drain-on leakage currents (5 vs 20 nA max), lower source-off leakage current (1 vs 5 nA), and a lower drain-to-source On resistance (130 vs 230Ω). These devices are 100% burned-in at 150°C. In a 16-pin plastic DIP, $4.30 (100).

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 403

MOTOR DRIVERS

The UC3620 and UC3622 motor-drive ICs feature decode logic that interfaces directly with TTL-compatible, Hall-effect position sensors; moreover, the devices have internal high-gain amplifiers and employ



switch-mode operation that minimizes power dissipation. The UC3620 uses fixed-off-time, current-mode control; the UC3622 has fixed-frequency, voltage-mode control. The devices are rated at 2A dc (3A pk), 40V. In a 25W, 15-lead package, $7.40 (100). Delivery, eight weeks ARO.

Unitrode, 7 Continental Blvd, Merrimack, NH 03054. Phone (603) 424-2410.

Circle No 404

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With Intel's New Development Tool for PCs. Hamilton/Avnet is proud to announce that the most reliable form of data storage is now even easier to use. We now offer the Intel PC-BUBBLE* Design Kit, to show you the fastest path to bubble memory design. It features the world's highest density bubble memory (Intel's 4 Mbit 7114) and Intel's special 4-SITE* development software.

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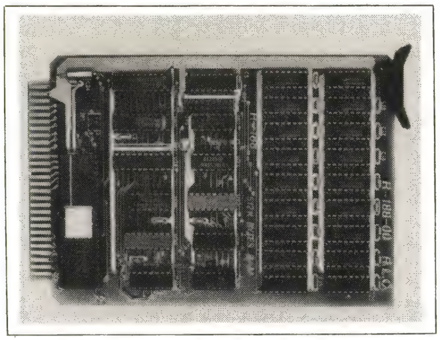


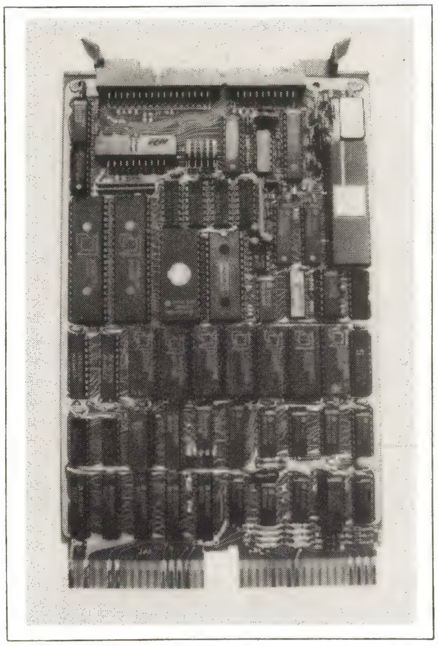
STD BUS CARD

The R-188, a 512k-byte dynamic-RAM card, works with 8-MHz CPUs and supports STD Bus 20-bit 8088 memory addressing. You can map the two 256k-byte blocks of memory into the 1M-byte address space on any jumper-selectable 256k-byte boundary. A RAM-controller chip performs onboard memory refresh. The card fully supports high-speed DMA to onboard memory in the byte, burst, or continuous modes. Onboard parity generation and checking will produce an interrupt on detected parity errors; strap options allow nonmaskable interrupts on parity errors. LEDs indicate onboard errors for each confirmation. 256k-byte board, $376.

RLC Enterprises, 1117 Hillview Dr, Milpitas, CA 95035. Phone (408) 946-7471.

Circle No 405

ST506 CONTROLLER



The SDC-RQD11-B Winchester controller uses the industry-standard ST506 disk-drive interface and communicates with the host computer via DEC's mass-storage control protocol (MSCP). You can connect two ST506-compatible, 5¼-in. Winchester disk drives to each controller; as many as three controllers can operate in one system. Using DEC's MSCP, this controller runs on standard operating systems without software modification. The device is hardware compatible with DEC's LSI-11 Series and MicroVAX I and II CPUs as well as Motorola 68000 and National 32032 Q Bus CPU designs. The module implements current Q Bus enhance-

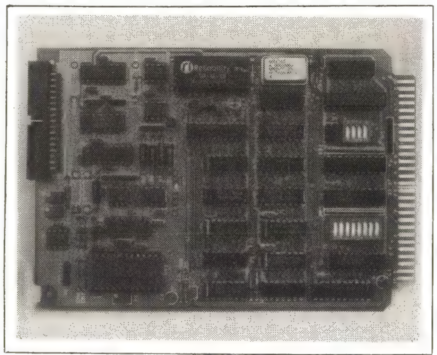
ments, including 22-bit addressing and block-mode DMA transfers. Other features include 32-bit error checking and correction, bad-block replacement, transparent read retry, automatic onboard bootstrap, data buffer, and LED indicators. $1295.

Sigma Information Systems, 3401 E La Palma Ave, Anaheim, CA 92806. Phone (714) 630-6553. TLX 298607.

Circle No 406

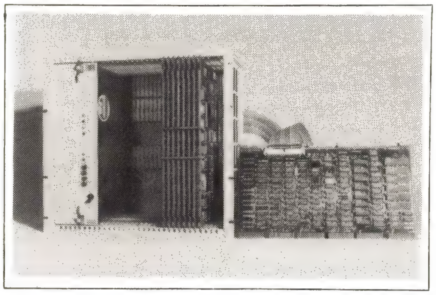
STD A/D CONVERTERS

Models 7110 and 7120, based on National Semiconductor's ADC 1205, are available for the STD Bus. These A/D converters feature high noise immunity, low power consumption, and 13-bit resolution (12 bits plus sign). Conversion time is 108 μsec. You can configure the inputs as 16 single-ended or eight differential channels; the input voltage range is −5 to +5V. Two channels can handle 4- to 20-mA or 10- to 50-mA inputs. Gain is hardware or software selectable. Prices start at $385.



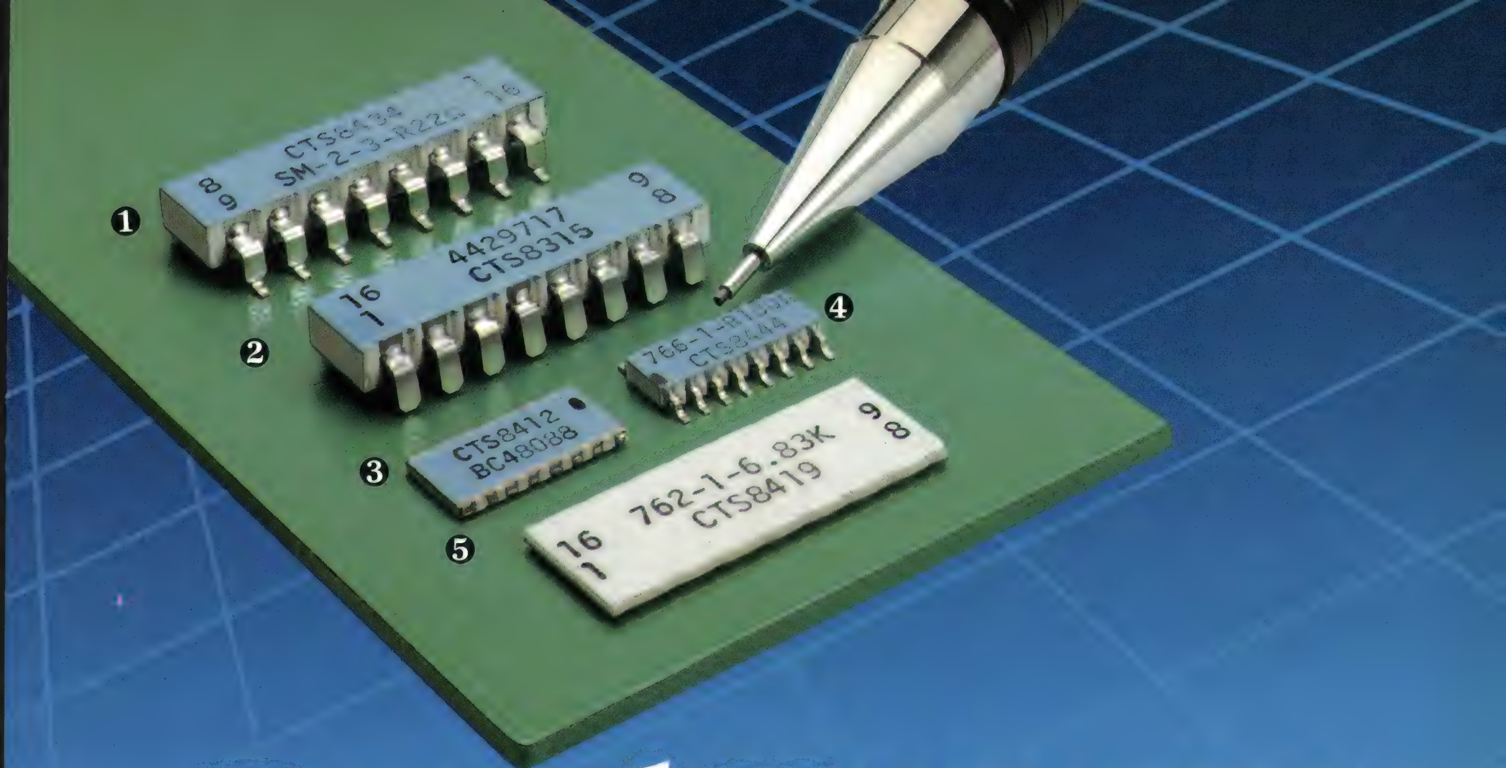
Cubit, 190 S Whisman Rd, Mountain View, CA 94041. Phone (415) 962-8237.

Circle No 407



UNIBUS RAM DISK

The N7000 semiconductor-based, disk-emulating memory specs an access time of 200 μsec, which increases memory access in Unibus-based computers tenfold, according to the manufacturer. The memory consists of a card cage that holds 4M-byte memory boards, allowing you to increase storage from 28M to 224M bytes. Two Unibus processors can access the dual-ported memory simultaneously, and the memory can transfer data at 1M byte/sec. The memory, which emulates DEC's RK07 disk system, is compatible with all DEC operating systems that operate with the RK611 Unibus disk controller. You can add



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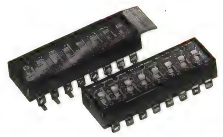

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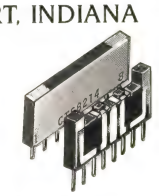

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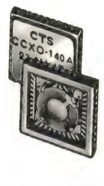

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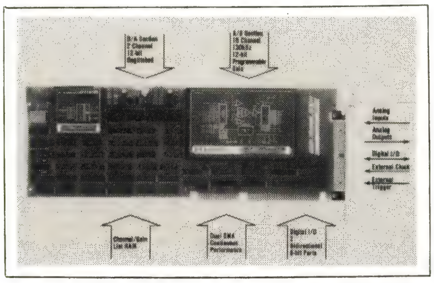
battery backup. Including a 1-year warranty, a 28M-byte version costs $39,500.

Nissho Electronics (USA) Corp, Inwood Park, Suite 200, 17310 Red Hill Ave, Irvine, CA 92714. Phone (714) 261-8811.

Circle No 408



DATA ACQUISITION

The DT2821-F data-acquisition board for the IBM PC/AT samples 16 single-ended or eight differential analog inputs at 130 kHz and specs 12-bit resolution. In addition, two 12-bit D/A-converter channels provide analog outputs at a 130-kHz throughput rate. For digital I/O, the board includes 16 I/O lines. The board supports five levels of interrupts and DMA transactions for communications with the PC/AT. You specify the sampled channels and the order of sampling in the board's channel-gain-list RAM. You can use a library of subroutines in the manufacturer's Atlab software package to write your applications software. DT2821-F, $1595; Atlab package, $449.

Data Translation Inc, 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 409

PC D/A CONVERTER

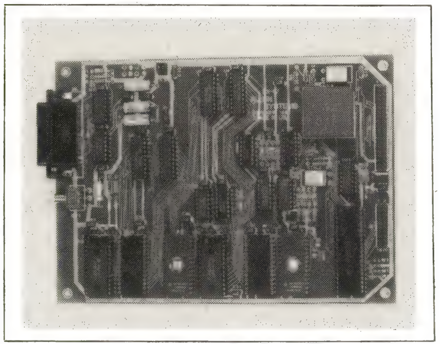
The PCI20021M-1 instrumentation module fits into the manufacturer's carrier boards, which plug into the IBM PC, PC/XT, or PC/AT. It provides eight channels of 12-bit D/A conversion, ½-LSB linearity, and 500-μsec settling time. Onboard RAM holds eight voltage values that a D/A converter consecutively

converts and stores in an S/H amplifier in one of the channels. The D/A converter refreshes data automatically. In addition, you can use onboard memory to store data setups. $495.

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 410

CIRCLE NO 60

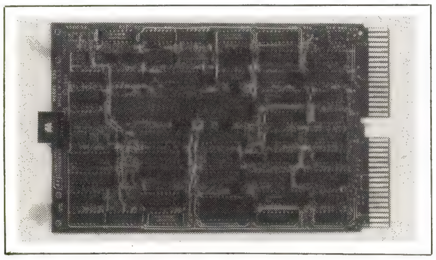


SINGLE-BOARD μC

The FX-97 single-board computer connects directly to a terminal and power supply so you can use it as a stand-alone system. The board includes two serial ports, eight analog inputs with 10-bit resolution, 32 parallel I/O lines, five counters, and 48k bytes of RAM, EPROM, or EEPROM. The 16-bit processor runs at 12 MHz. Available with the FX-97 is a system monitor to simplify program testing and debugging. The monitor lets you download software from a host computer. A resident interpretive Basic package is also available for writing programs without a host computer. The board measures 5.75×8 in. Assembled and tested, $425; bare board, $75.

Allen Systems, 2151 Fairfax Rd, Columbus, OH 43221. Phone (614) 488-7122.

Circle No 411



SYSTEMS BOARD

The Model 305 multifunction systems board includes a DLV-equivalent console-interface port, a software-programmable watchdog timer, and time clock. Diagnostic bootstrap PROMs for such I/O and storage devices as DECnet, RK06, RL01/RL02, TU58, RX01, and RX02 are optional. The device also includes 4-level interrupt processing and 22-bit addressing. Compatible with the DEC Q Bus microcomputer series, it comes on a dual-height board that measures 8.9×5.2 in. $450.

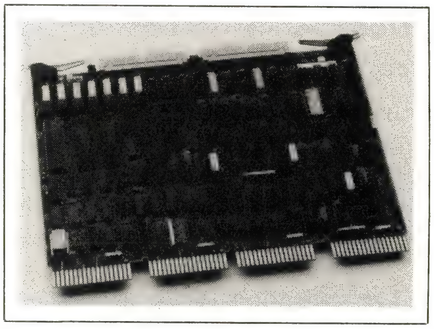
Computer Products, Grant Technology Div, 11 Summer St, Chelmsford, MA 01824. Phone (617) 256-8881.

Circle No 412

TAPE COUPLER

The DQ142 tape coupler connects ½-in. tape drives to DEC LSI-11 and Micro PDP-11 computers. It has a 4k-byte FIFO buffer and can switch-select DMA burst size to either two or four words. Users can attach virtually any 9-track, ½-in. magnetic tape drive to an LSI-11 system, and they can configure as

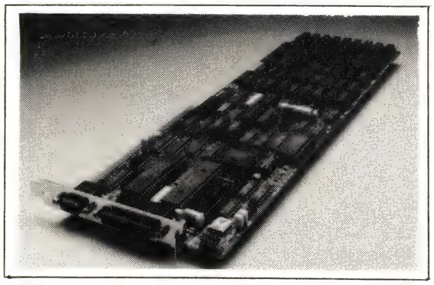
many as four tape drives per coupler. The tape coupler can connect to 800-bpi NRZ drives, 1600-bpi phase-encoded drives, and 6250-bpi group-code-recording (GCR) drives, as well as dual-density (1600/3200 bpi) and tridensity (800/1600/3200 bpi) drives. A 2901 bipolar μP implements controller functions, and an automatic self-test



feature initiates onboard diagnostics at power-up. Operating over ambient temperatures between 50 and 140°F and humidity ranging from 10 to 90%, the quad-sized tape coupler draws 4A at 5V from the CPU power supply. It provides TS-11/TSVO5 subsystem compatibility using DEC operating systems, including RT-11, RSX11M, and RSTS. $1260 (OEM qty).

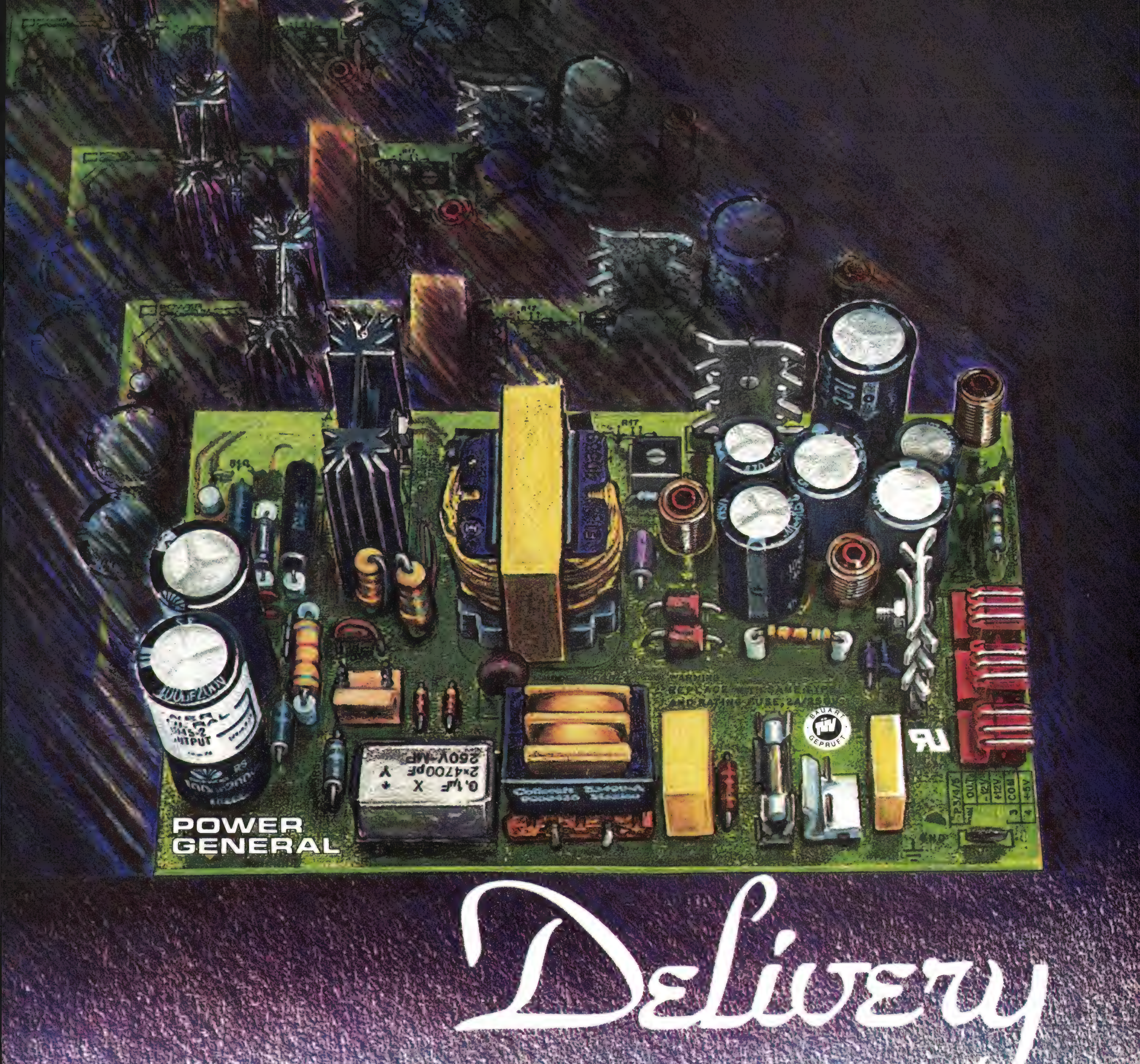
Distributed Logic Corp, Box 6270, Anaheim, CA 92806. Phone (714) 937-5700. TLX 6836051.

Circle No 413



PC/AT BOARDS

The Persyst Mono Combo/AT and Persyst Color Combo/AT boards supply I/O ports, memory, and a display adapter to the IBM PC/AT. The Mono Combo/AT module includes a parallel port, an asynchronous serial port, 128k to 1.5M bytes of memory, and a monochrome-display adapter. The adapter drives IBM's monochrome screen and is software compatible with IBM's Monochrome Display Adapter, according to the manufacturer. The Color Combo/AT module offers the same parallel port, serial port, and memory as the Mono Combo/AT but has a color-graphics-display adapter instead of monochrome. The color-graphics-display adapter is fully compatible with the IBM Color/Graphics Adapter. You can assign all of the 1.5M bytes of memory to the PC/AT's extended (more than 1M-byte) memory, or you can split the assignation between the extended and base (256k to 640k bytes) memory. This choice makes the Combo/ATs suitable for DOS applications, which use base memo-



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GA	919-722-9445	NM	602-994-5153	TX	512-459-0802
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IL	312-991-2144	NY	518-274-4758	VT	617-449-7400
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IA	319-365-8071	NY	716-223-1030	VA	800-239-8486
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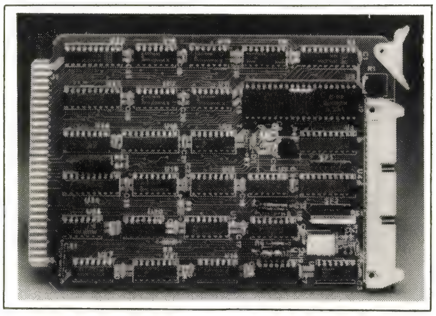
CIRCLE NO 225

ry, and for operating systems that use the extended memory (eg, Xenix). Either board, including 128k bytes of RAM, $595.

Emulex Corp, Box 6725, Costa Mesa, CA 92626. Phone (800) 368-5393; in CA, (714) 662-5600.

Circle No 414

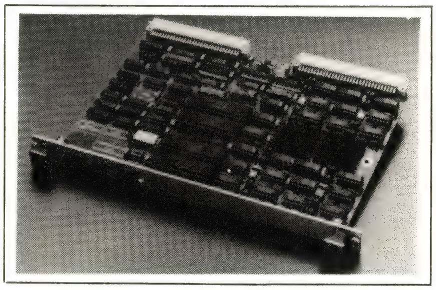


STD BUS CONTROLLER

The FLP-380 floppy-disk-controller card for the STD Bus can control 6.6M-byte, 5¼-in.; 1M-byte, 3½-in; and 8-in. floppy-disk drives. The controller is available in a CMOS version for low-power applications. With read, write, and format functions that are software configurable, you can mix and match drive types and formats within the same system. Using a DMA circuit, this controller can interface to a Z80 CPU with clock speeds greater than 8 MHz. It can accommodate single- or double-sided drives, and single- or double-density operation. Software support includes the BIOS for CP/M 2.2 and MP/M. $232 (OEM qty).

Computer Dynamics Inc, 105 S Main St, Greer, SC 29651. Phone (803) 877-7471.

Circle No 415

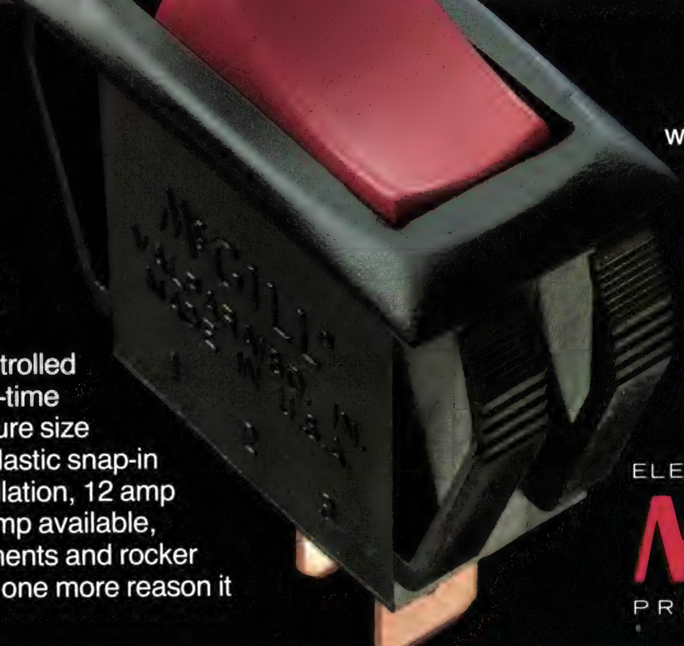


SERIAL CONTROLLER

The V/SIO 3208 is a serial communications controller with eight independent, full-duplex RS-232C channels on a single VME Bus board. Four software-programmable interrupts for each of the eight channels help to increase the throughput rate. The unit offers programmable baud rates from 50 to 19.2k bps; modem control; asynchronous, synchronous, and SDLC bit-synchronous modes; local loop-back; and auto-echo modes. It also provides 32- or 24-bit addressing. Two RS-232C ports, on individual headers on the card front and on the P2 standard DIN connector on the back, are provided. $795.

Interphase Corp, 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000. TLX 732561.

Circle No 416



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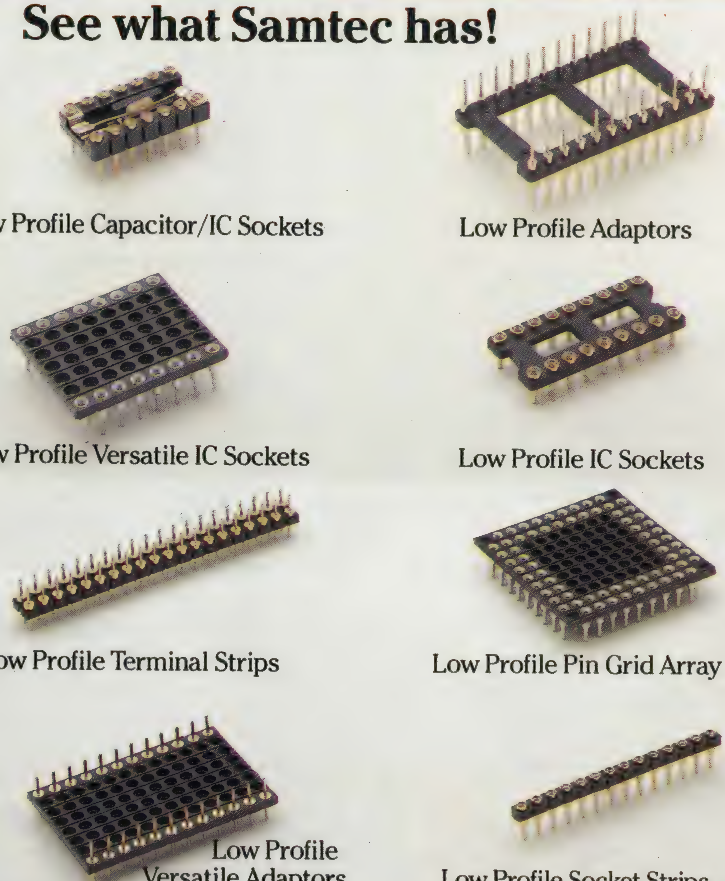

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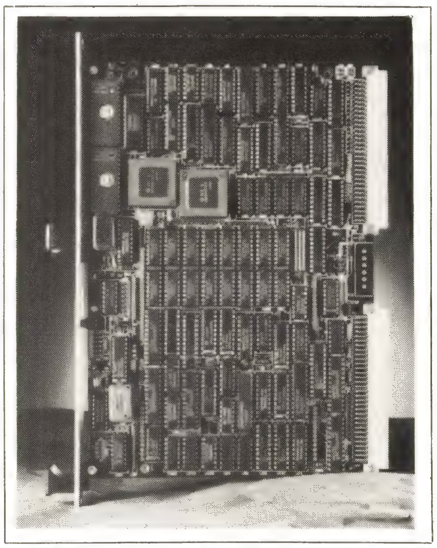
software includes Grealstar for the generation of nonstandard tests, and Loadstar, which allows you to use the system in an interactive mode. Optional hardware includes a 750-VA solid-state ac source, a multichannel timing module, a module for measuring ripple and noise, and a 0 to 75V, 100W dc source. From approximately £20,000.

Intepro Systems Ltd, Plassey Technological Park, Castletroy, Limerick, Ireland. Phone (353) 61-332233. TLX 70110.

Circle No 421

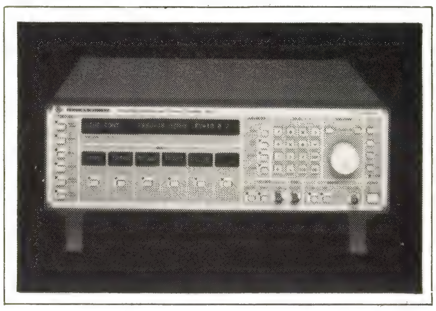
DISK-CONTROL BOARD



The CT-68VIDC has an onboard 68000 or 68010 μP that executes a firmware disk-caching algorithm for high-speed access to 5¼-in. disk drives on its SCSI interface. A 2- or 4-channel DMA controller allows SCSI bus data-transfer rates as high as 1.5M bytes/sec. Versions are available with either 128k or 512k bytes of dual-ported memory, which you can expand to 2M bytes by adding a daughter board. Space is also provided for as much as 128k bytes of onboard EPROM. The board has an MMU and a VME Bus master-to-slave interface that includes a single-level bus arbiter and interrupt handler. A programmable interval timer and self-test firmware are also included. $2000.

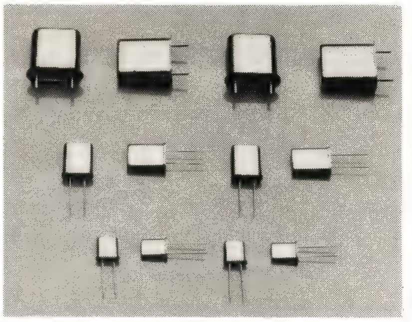
Integrated Micro Products Ltd, Number One Industrial Estate, Medomsley Road, Consett, DH8 6TJ, UK. Phone (0207) 503481. TLX 53429.

Circle No 422



FUNCTION GENERATOR

The AFG function generator, which incorporates a 40-digit alphanumeric display, provides a soft-key, menu-driven set-up procedure. It also has full IEEE-488 bus control. The generator produces sine, trian-



CRYSTALS

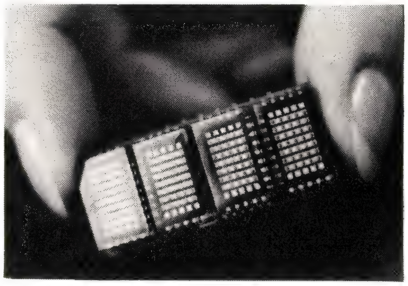
The QCX Series crystals are available in the frequency range from 1 to 48 MHz. All of the crystals feature a frequency tolerance at 25°C of ±50 ppm, a frequency stability of ±50 ppm over a −20 to +70°C range, and an aging rate of 5 ppm/year. Maximum shunt capacitance equals 7 pF. Crystals with frequencies between 1 and 3.5 MHz are available in HC-33/U cases, between 2 and 48 MHz in HC-49/U cases, and between 6 and 24 MHz in UM-1 cases. £0.47 to £2.54 (1000).

STC Components Ltd, Quartz Crystal Unit, Edinburgh Way, Harlow, Essex CM20 2DE, UK. Phone (0279) 26811. TLX 818746.

Circle No 417

Stantel Components, 636 Remington Rd, Schaumberg, IL 60195. Phone (312) 490-7150.

Circle No 418



LED DISPLAY

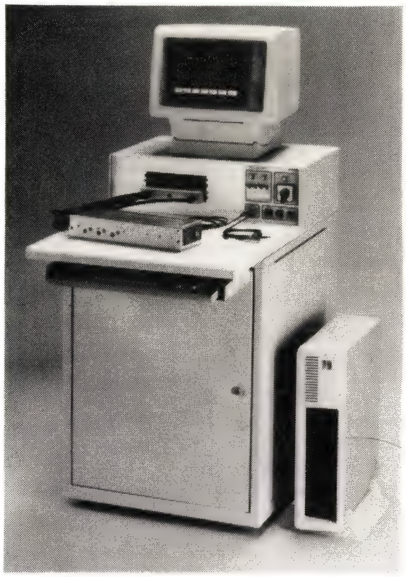
The PD-3435 and -3437 are orange and green versions, respectively, of a 4-digit, dot-matrix LED display. The 5×7-dot matrix has a character height of 7 mm. Integral character memory, character generator, display multiplexing, and driver circuitry allow you to display 96 characters from the ASCII character set. Additional features include blinking, display testing, and programmable brightness control. PD3435, DM 107; PD3437, DM 117 (99).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 419

Siemens Components Inc, 186 Wood Ave S, Iselin, NJ 08830. Phone (201) 321-3400.

Circle No 420



SUPPLY TESTER

The Model 3600 includes the hardware and software necessary to test power supplies with ratings to 300W. Running on an IBM PC, the Powerstar software provides you with 38 standard power supply tests that you can set up by entering the required test limits. The system's hardware components include a 1-kVA motorized variac; four 30A/150W loads; a 5-digit DVM with rms ac current- and voltage-measurement capability; a counter/timer; a 14-channel DVM-input scanner and a 2-channel counter/timer-input scanner; and six free and configurable power relays. The unit's front panel includes test-fixture connectors and test-probe inputs. Optional

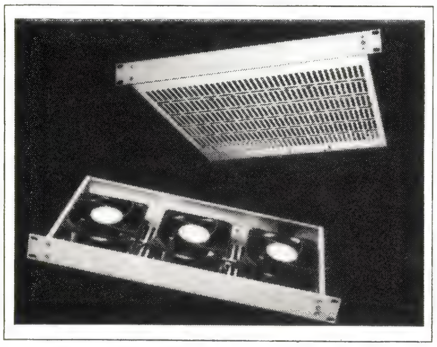
gle, and square waveforms in the 0.01-Hz to 20-MHz frequency range. It also produces trapezoidal and pulse signals. Its sine-wave harmonic ratio is >50 dB from 20 Hz to 100 kHz, and its triangular-wave linearity is <0.2% at frequencies to 1 kHz. You can set the 50Ω output level between 0 and 10V p-p and offset the output by as much as ±5V dc. In the 1 to 10V range, the output-amplitude accuracy at 10 kHz is 2%. Voltage control of the frequency is possible from an external source. In addition, you can amplitude-modulate, frequency-modulate, or pulse-modulate the output and generate an FSK output signal. You can control pulse modulation and FSK from either an internal or external source. DM 13,440.

Rohde & Schwarz GmbH, Mühldorfstr 15, 8000 Munich 80, West Germany. Phone (089) 41290. TLX 523703.

Circle No 423

Rohde & Schwarz Inc, 13 Nevada Dr, Lake Success, NY 11042. Phone (516) 488-7300.

Circle No 424



FAN TRAY

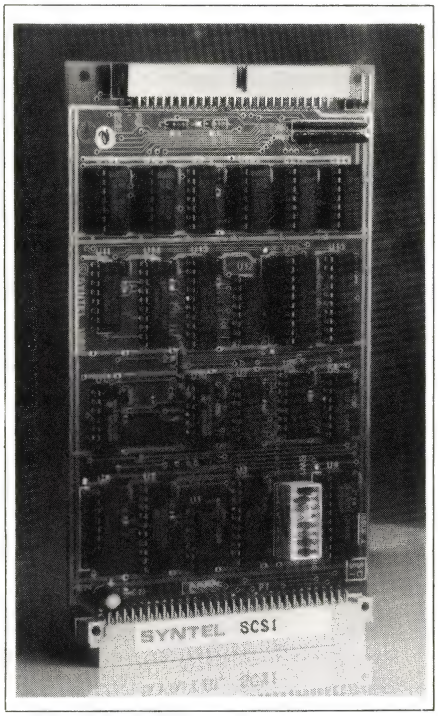
This 1U-high fan or component tray for 19-in. rack-mounted systems comes in 208- and 460-mm-deep versions. The trays are prepunched with air vents that double as fan-mounting holes and finger guards. The 208-mm-deep version accommodates as many as three standard 120-mm² fans, and the 460-mm deep version holds as many as nine of those fans. Alternatively, you can use the trays for other assemblies, such as pc boards or power sources. The trays are manufactured from zinc-plated steel with an anodized front panel and are supplied with a CEE22 power socket at the rear. Accessories include a filter unit and narrow slides that allow you to slide each tray in and out of the rack for maintenance. The 208-mm fan tray, including three ac fans, sells for under £100.

Bicc-Vero Electronics Ltd, Flanders Rd, Hedge End, Southampton SO3 3LG, UK. Phone (04892) 81424. TLX 477984.

Circle No 425

Bicc-Vero Electronics Inc, 40 Lindeman Dr, Trumbull, CT 06611. Phone (203) 372-0038.

Circle No 426



SCSI BUS CARD

The Syn-SCSI single Eurocard board furnishes an interface for G64 Bus computer systems to SCSI bus peripherals such as hard-disk, floppy-disk, or tape drives. The board automatically acknowledges SCSI bus transfers, speeding data throughput. You can also accelerate the board's throughput by using it with a separate DMA controller. The SCSI bus interface provides only local access to one or more peripherals; it's configured as a single-ended communications option without parity or arbitration logic. £169.

Syntel Microsystems, Queens Mill Road, Huddersfield HD1 3PG, UK. Phone (0484) 535101. TLX 51194.

Circle No 427

SEMICUSTOM SUPPLY

This semicustom supply comes on two universal pc boards and provides a range of voltage and power outputs. The primary side of the supply, an auxiliary regulation coil, and the first output winding are standard on one pc board; the other board accommodates the output op-

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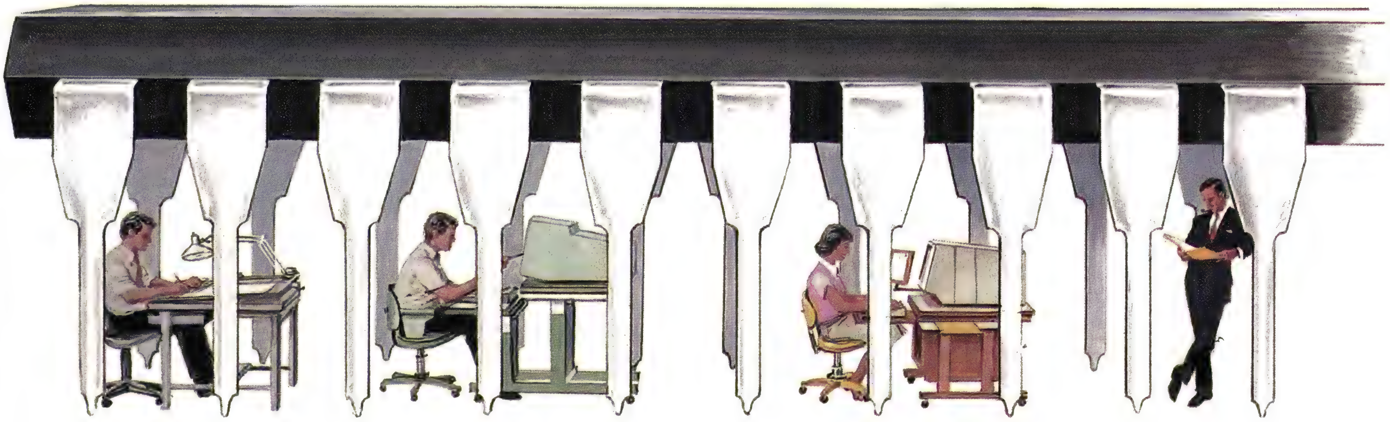

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CP/M™-80, CP/M-86 .... $249

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8048/8041	COP400	68020
8051	F8/3870	68000/68010

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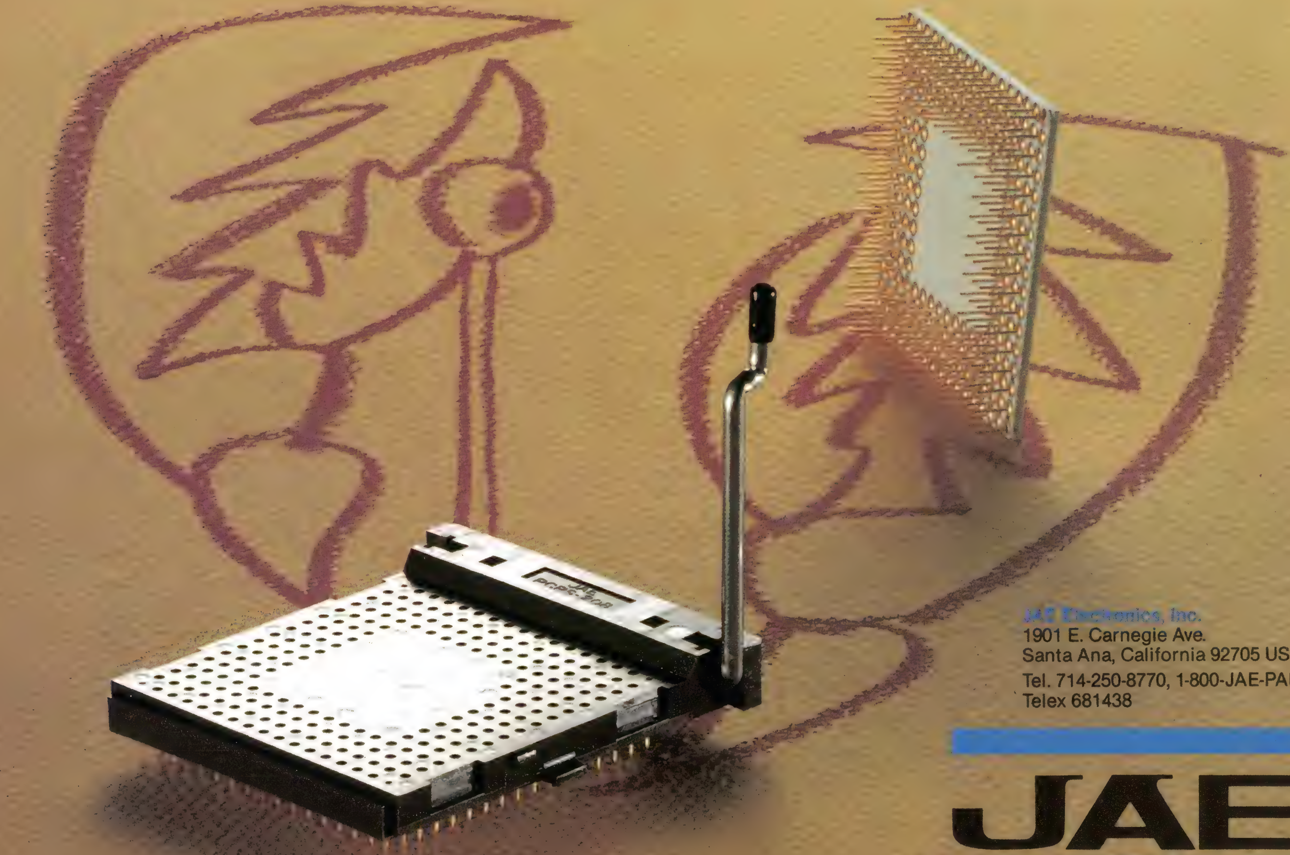


JAE Electronics, Inc.
1901 E. Carnegie Ave.
Santa Ana, California 92705 USA
Tel. 714-250-8770, 1-800-JAE-PART
Telex 681438

JAE

Japan Aviation Electronics Industry, Limited

21-6, 1-chome Dogenzaka
Shibuya-ku, Tokyo 150, JAPAN
Tel. 03-463-3111

CIRCLE NO 230

tions. The supply comes in seven basic designs, including 100 to 150W, 100 to 300W, and >300W multiple-output units; 60W multiple- or single-output units; and 100 to 300W single-output units. The vendor also offers backup and standby supplies and 100 to 200W multiple-output dc/dc converters. Nonrecurring engineering costs for a typical design are around gld 15,000.

Philips, Electro-Acoustic Systems Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 428

BENCHTOP ATE

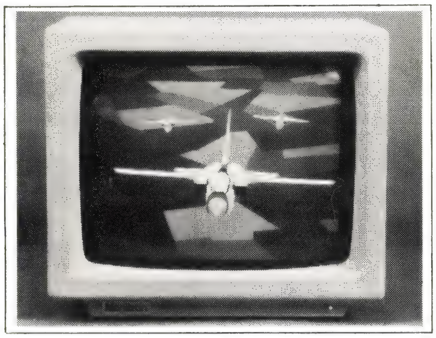
The Checkmate ATE system can perform digital tests, functional analog tests, and in-circuit tests. The modular tester, which includes a high-resolution color monitor and two 3½-in. floppy-disk drives, accepts as many as 21 analog and digital measurement or function cards. Dry-reed or mercury-wetted relay cards are provided for signal routing. You can configure the system with two or more independent sets of digital function cards to perform asynchronous testing. Six-wire guarded measurements allow you to diagnose faults at the component level. You program this system using the Climate ATE language. The unit accepts either vacuum-actuated bed-of-nails or platen-type test fixtures. £20,000 to £30,000.

Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN, UK. Phone (0727) 59292. TLX 23350.

Circle No 429

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Phone (201) 934-9050.

Circle No 430



COLOR MONITOR

Designed for high-resolution graphics applications, the CLR20 color monitor features a line-scan rate of 64 kHz and a usable resolution of

1280×1024 pixels. You can adjust the frame rate within the 50- to 120-Hz range; the monitor has a frame-blanking period of 800 μsec and a line-blanking period of 3.7 μsec. You can choose either an interlaced or a noninterlaced scan mode. The monitor's small-signal bandwidth is >100 MHz. You can synchronize the scan by using either a composite synchronous input or separate TTL-compatible line and frame synchronous inputs. The monitor operates from a 190 to 265V ac line input. £1800.

Ficention Ltd, Manitron Div, Bold Street, Sandbach, Cheshire CW11 9AR, UK. Phone (0270) 764171. TLX 367227.

Circle No 431

MEMORY MODULES

The HM44256P1 and HM44257P1 are 256k×4-bit dynamic-RAM modules housed in 22-pin SIPs. The HM44256P1 has page-mode access, and the HM44257P1 has nibble-mode access. Both devices are available in 100-, 120-, or 150-nsec access-time versions. They are constructed from four dynamic RAMs, which are packaged in plastic leaded chip carriers and mounted on a fiber-glass mother board together with decoupling capacitors. The modules measure 61×11.4×5 mm and feature common I/O with early write, 256-cycle RAS-only refresh, and hidden refresh. They operate from one 5V supply. £26 (500).

Hybrid Memory Products Ltd, W Chirton Industrial Estate, North Shields, Tyne & Wear NE29 8SE, UK. Phone (0632) 580690. TLX 53206.

Circle No 432

MODEM

The Tm512E autodial, autoanswer modem operates on CCITT standards V21 (300/300 bps full duplex), V23 (1200/75 bps, 75/1200 bps, and 1200/1200 bps half duplex), and Bell transmission standards. It includes the Epad (Error-Protected Packet Assembler/Disassembler) error-checking protocol for use on the Packet Switch Stream (PSS) network; the vendor claims this protocol allows for error-free data transfer to and from a terminal or computer and the packet assembler/disassembler. The Epad facility uses the Epad notes to enable transmission over the whole PSS network. The modem also features automatic baud rate, parity detection on the local terminal or computer link and on the telephone line, and automatic selection of pulse or tone dialing. £339.

Tandata Marketing Ltd, Albert Rd N, Malvern, Worcs WR14 2TL, UK. Phone (06845) 68421. TLX 337617.

Circle No 433

ADVANCED PRECISION AC POWER SYSTEMS

for a Wide Range of Applications from Reliable Burn-in Power to Precision Testing

The important factors in the selection of an AC power supply: space, efficiency, safety, power bandwidth, modularity and cost have all been thoughtfully incorporated into the XP Series AC Power Systems.

The XP Series System is made up of three interchangeable components: power amplifier, power controller and power monitor.

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Choose from four XP Series Power Amplifiers. All are compact and can be stacked in two-phase, three-phase open delta and three-phase WYE configurations.

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- Full rated power from 45 Hz to 5,000 Hz and optional bandwidth to 10,000 Hz
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POWER CONTROLLERS

Five versatile power controllers cover the needs of every AC power source application. From the simplest, the 910XP which provides crystal-controlled fixed-frequency to the top of the line, the powerful 949XP which provides total control and programmability of the AC power System.

- Crystal-controlled, synthesized frequency in increments as fine as 0.1 Hz
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- Overload and overtemp indicators
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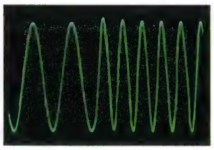
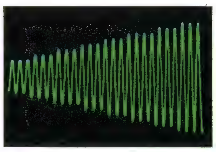
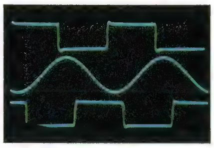
With over 25 years of experience, California Instruments is unmatched in the precision AC power systems to meet stringent requirements. Get precision testing power into your applications by calling today for assistance and a complete catalog.



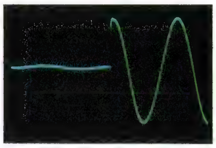
Programmable Frequency



Amplitude Ramp/Step



Multi-Phase Waveform



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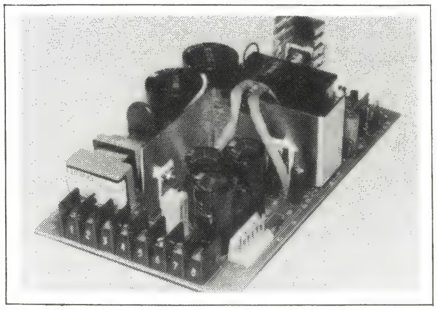
CIRCLE NO 231

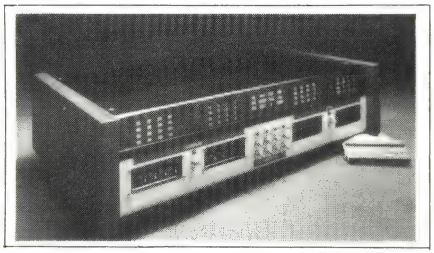


75W SWITCHERS

The 7S75 family of 75W open-frame switching power supplies provides regulated outputs of 5, 12, 15, or 24V dc. The supplies are recognized under UL 478, certified to CSA 22.2, and approved to VDE 0806 (IEC 380) for SELV applications. Conducted noise complies with FCC Docket 20780 level B and VDE 0871 level B. The supplies include protection against overload, short circuit, reverse polarity, and overvoltage. Output voltages are adjustable over ±5%, and maximum output ripple and noise is 1% of the nominal output. The supplies exhibit load and line regulation of 0.2%. The devices accept input voltages ranging from 90 to 132V ac and 180 to 264V ac (47 to 63 Hz) and measure 7.25×4.25×1.95 in. $66 (1000). Delivery, 12 to 16 wks ARO.

Sierracin/Power Systems, 20500 Plummer St, Chatsworth, CA 91311. Phone (818) 998-9873.

Circle No 434



STATIC STIMULATOR

With the CSA SSLA logic stimulator, you can manually exercise all the address, data, and control lines of your μP-based project. The CSA has adapters for 68000/10/20 and 8086/186/286 μPs' sockets as well as the VME Bus, Multibus, and Versabus. The unit offers remote control via an RS-232C interface. The remote-control feature allows you to perform low-speed emulation. $3850; additional adapter cables, $180.

Computer System Associates Inc, 7564 Trade St, San Diego, CA 92121. Phone (619) 566-3911. TLX 333693.

Circle No 435

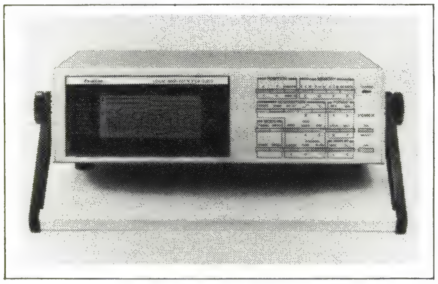
COIL CHECKER

The STT-4 detects shorted turns in coils and works with a large range of coil and wire sizes. A variety of probes are available to accommodate different coils and wire gauges. Probes from 1/16 in. in diameter for miniature sizes to ½×4 in. long are standard. You can control the go/no-go limit adjust and the volume of the

5-kHz alarm from the back panel. The device draws 30W from a 115V±10%, 50/60-Hz supply. $850.

International Electro-Magnetics Inc, 350 N Eric Dr, Palatine, IL 60067. Phone (312) 358-4622. TLX 726329.

Circle No 436



LOGIC ANALYZER

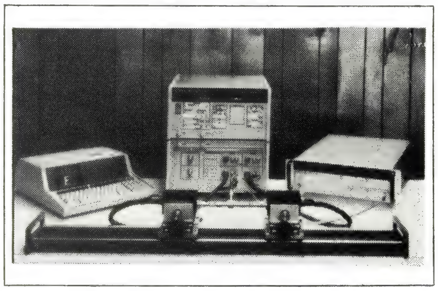
The Primeline PLA-3300 logic analyzer performs state, timing, and signature analysis. It has an LCD readout and operates from line power without an ac adapter or from a built-in NiCd battery. The device features a 10-MHz clock rate, 16 channels for data input with 256 bits/channel of acquisition memory, a reference memory of 256 bits/channel, 15-nsec glitch detection, and 100-nsec resolution. $1995.

Soltec Distribution, Box 818, Sun Valley, CA 91353. Phone (818) 764-5400. TLX 4943094.

Circle No 437

SIGNAL GENERATOR

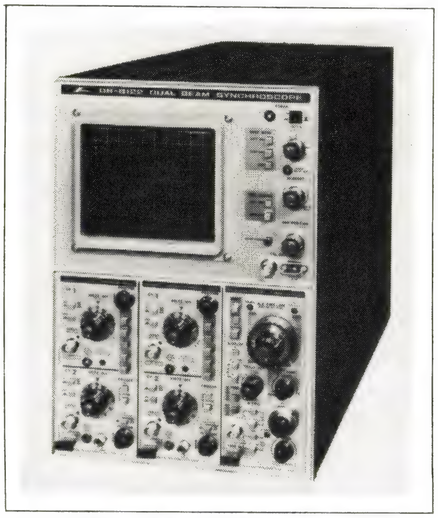
The VM-4B signal generator/calibrator features a 0.01- to 18.0-GHz frequency range (expandable to 40 GHz) and a dynamic range greater than 100 dB. The instrument provides dual- or single-channel operation; dual-channel measurement accuracy is ±0.02 dB (per 10 dB, exclusive of mismatch uncertainty). You can select 0.1-, 0.01-, or 0.001-dB measurement resolution. For dual-channel phase measurements, the specs are: ±180° range; 1.0, 0.1,



and 0.01° resolution; and ±2.5° accuracy (exclusive of mismatch uncertainty). Typical measurement time for a −130-dBm signal is 18 msec. System repeatability for magnitude is ±0.015 dB max, ±0.008 dB typ; for phase, it's ±0.5° max, ±0.25° typ. Load VSWR is 1.27 at 18.0 GHz with a masking attenuator (1.15 typ); source VSWR is 1.15 at 18 GHz (less than 1.10 typ). $74,700. Delivery, four months ARO.

Weinschel Engineering, 1 Weinschel Lane, Gaithersburg, MD 20877. Phone (301) 940-3434. TLX 440702.

Circle No 438



SCOPE MAINFRAME

The DS-8122 accepts as many as three plug-in units. A 1-gun, 2-beam CRT makes it possible to observe two high-speed, single-shot events simultaneously or to observe four traces at the same time when two vertical dual-input units are plugged in. The mainframe incorporates a character generator to display the data from the plug-in units on a 6-in. CRT. Plug-ins include a dual-trace amplifier (100 MHz), differential-input amplifier (10-μV/div sensitivity), dual timebase with delayed sweep, and a 1-GHz sampling front end. The device measures 8¾×12⅜×20½ in. $6920. Delivery, 10 to 12 weeks ARO.

Iwatsu Instruments, 430 Commerce Rd, Carlstadt, NJ 07072. Phone (201) 935-5220.

Circle No 439

29PL141 EMULATOR

The MM141 works with an IBM PC to support development of AMD's 29PL141 microcontroller. The emulator connects to the IBM PC via a flat cable. The package includes an

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Our portable resident and interface libraries have been enhanced to support the 1984 /usr/group standard system calls, ensuring UNIX source code compatibility. IDRIS now supports environments, FIFO files and pipes, file locking, process groups, no delay I/O, System V style termio, curses, termcap and more.

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* IDRIS TARGET SYSTEM, a runtime environment for disk-based turnkey and dedicated systems, offers the complete executive and all utilities except program development tools.
* IDRIS DISK-BASED EXECUTIVE is the complete executive without the Whitesmiths-supported utilities.
* IDRIS EMBEDDED EXECUTIVE is a trimmed down executive designed for use in board-level products without a disk.

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	MC 68000	INTEL 80 x 86*	DEC VAX +
DEVELOPMENT SYSTEM	X	X	X
TARGET SYSTEM	X	X	X
DISK-BASED SYSTEM	X	X	X
EMBEDDED EXECUTIVE	X		

* Cohabitates with DOS
+ Cohabitates with VMS

CIRCLE NO 233

editor and assembler, a writable control store, a real-time emulator, and real-time trace. Given the 29PL141's fixed-instruction format, you need only fill in highlighted fields in edit mode to write programs. You enter emulator commands as single keystrokes. The error messages contain specific information about invalid entries, thus serving as an on-line help facility. Two maskable trace-point registers and a delay counter control operation of the 2k-word×32-bit trace memory. $4995. Delivery, 60 days ARO.

HLA Instruments, 5667 Snell Avenue, Suite 218, San Jose, CA 95123. Phone (408) 726-2050.

Circle No 440

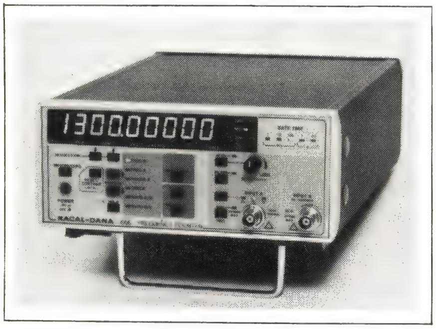
COMPONENT COOLER

The Cold Gun component cooler produces a stream of clean, cold air at −40°C by passing compressed air through a vortex tube. The tube divides the compressed air into a hot and a cold stream, and an articulated nozzle directs the cold stream in a narrow pattern at the component under test. The cooler has no moving parts and requires no electricity or chemicals. An ordinary supply of compressed air is the only power source, and a thumb-actuated air valve permits intermittent use. The cooler eliminates the expense of Freon and the associated thermal-shock damage caused by cryogenic Freon temperatures when thermal

testing ICs, resistors, and other electronic components. $119.

Exxair Corp, 419 Findlay St, Cincinnati, OH 45214. Phone (513) 381-4388.

Circle No 441



FREQUENCY COUNTER

Model 1998 features a 1-sec response for 9-digit resolution over its 10-Hz to 1.3-GHz frequency range. Depending on the degree of resolution and speed of measurement required, you can vary displayed resolution from three to 10 digits. The counter features a burst-frequency capability that allows 6-digit resolution for signals as short as 2 msec. In addition, it offers period, ratio, and nulling capabilities. The nulling capability enables you to make measurements relative to any previously measured value. Other features include fixed-attenuator and variable-sensitivity controls. A rechargeable battery option for field operations includes an external 11 to 16V dc input for connection to a dc supply such as a vehicle battery. An IEEE-488 capability is also optional. $1325.

Racal-Dana Instruments Inc, Box C-19541, Irvine, CA 92713. Phone (714) 859-8999. TWX 910-595-1136.

Circle No 442

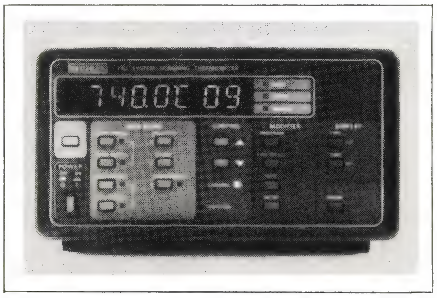
68020 SOFTWARE

The Oasys 68020 cross-development Toolkit features a set of compilers, assemblers, debuggers, simulators, profilers, a real-time operating system, and utilities for downloading

programs. The compilers included are C, Pascal, and Fortran 77. The assemblers include linker, loaders, and librarian. In addition, the package supports the 68881 floating-point processor. The software runs on DEC VAX and MicroVAX (VMS, Ultrix, Unix), Sun, Apollo, Pyramid and other 68000- and 32000-based systems running Unix. $3200.

Oasys, 60 Aberdeen Ave, Cambridge, MA 02138. Phone (617) 491-4180.

Circle No 443



THERMOMETER

The Model 740 programmable scanning thermometer can linearize inputs from the seven thermocouple types (J, K, T, E, R, S, and B) and includes a separate microvolt range for nonstandard thermocouples. It supports as many as 81 channels, scans at 20 channels/sec, and includes a 100-reading, nonvolatile data memory. It features a built-in cold-junction reference, eight alphanumeric LED displays with °C or °F scale selection, a built-in IEEE-488 interface, digital calibration, a print feature, programmable alarm limits, and a real-time 24-hour clock. The device's accuracy is better than 0.5°C, and its resolution is 0.1°C or 0.1°F. You can use a selectable analog filter to provide an additional 20 dB of normal- and common-mode rejection at power-line frequencies. $1350.

Keithley Instruments, Instruments Div, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400.

Circle No 444

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LEMO B Series quality connectors available in multicontact from 2 to 64 contacts, or unique coaxial-multicontact, or high voltage multicontact configurations

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SPACE SAVINGS: Only finger clearance on two sides needed to engage and disengage connectors. No need to twist or turn locking ring.

RELIABILITY: Key/Keyway pattern provides mating exclusivity. Quick-Lok mechanism assures secure contact by audible click when lock is engaged. Color coding is available too.

RUGGEDNESS: Connector components are precision machined from brass bar and tubing stock, plated with copper and then nickel. Locking mechanism is totally protected by outer shell, virtually eliminating accidental disconnections, damage to locking mechanism, cables and contacts.

AESTHETIC-FUNCTIONAL DESIGN: Outer shell and back nut finished with matte chrome plating. Contacts are gold plated. LEMO connectors will complement any front panel application.

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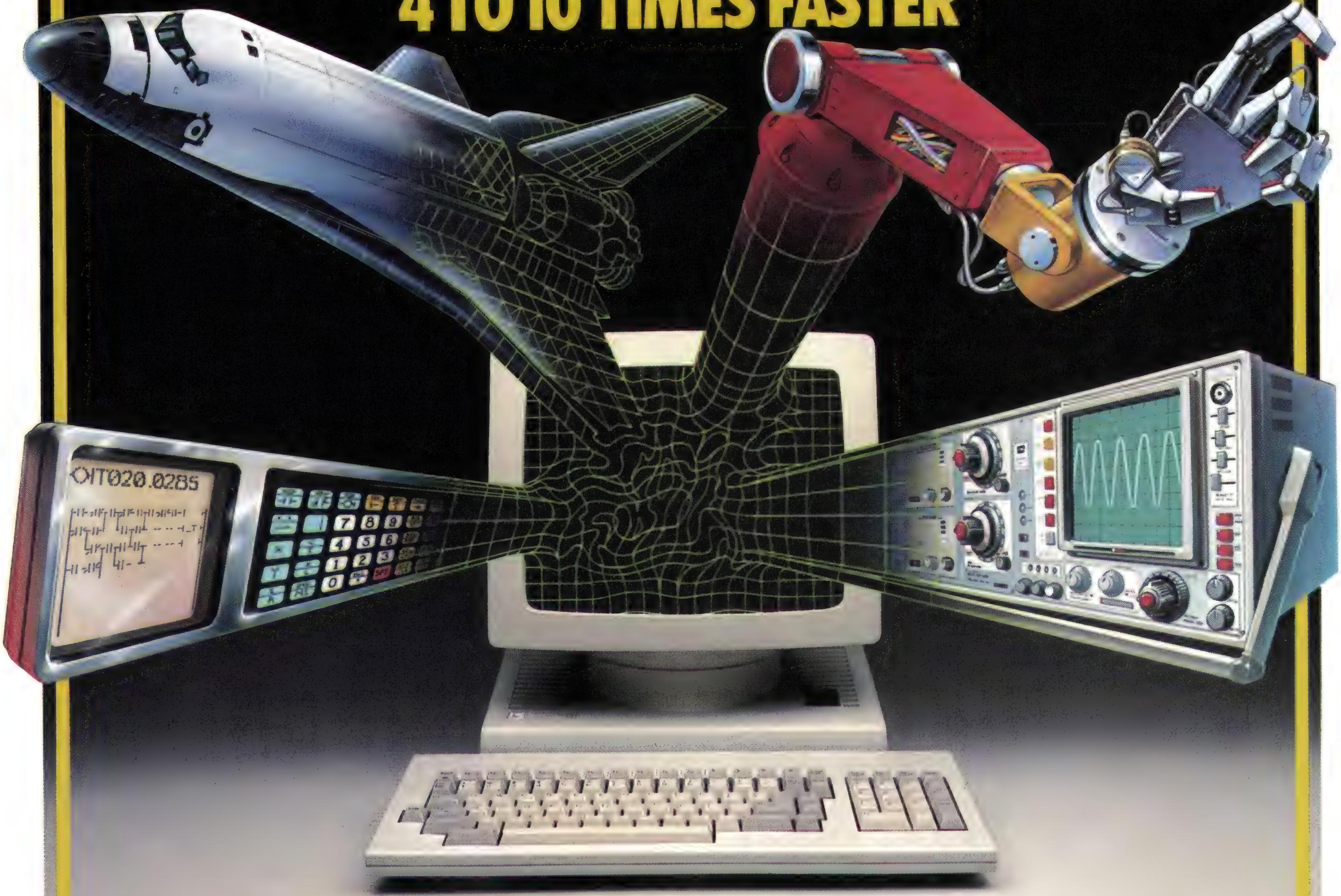
CIRCLE NO 288

polyFORTH GETS YOUR PROGRAM FROM CONCEPT TO REALITY 4 TO 10 TIMES FASTER



THE ONLY INTEGRATED SOFTWARE DEVELOPMENT PACKAGE DESIGNED FOR REAL-TIME APPLICATIONS

If you're a real-time software developer, polyFORTH can be your best ally in getting your program up and running on time. In fact, on the average, you will develop a program 4 to 10 times faster than with traditional programming languages.

But you don't have to take our word for it—just ask our customers. We'll tell you who they are. They're some of the largest and most successful companies in high technology fields such as aerospace, robotics and machine vision, instrumentation, process control, and more.

polyFORTH shortens development time by making the best use of your time. There are no long waits while you load editors, compilers, assemblers, and other tools, not to mention the long waits while they run—because everything you need is in a single, easy-to-use, 100% resident system. Using polyFORTH, you take a raw idea to fast, compiled code in seconds—and then test it interactively.

polyFORTH's total programming environment has all the tools you need to develop real-time applications: fast multi-tasking, multi-user OS; FORTH compiler, interpreters, and assemblers; editor and utilities; and over 400 primitives and debugging aids. And because of its unique modular structure, polyFORTH even helps you test and debug custom hardware interactively.

polyFORTH is available for most 8, 16, and 32-bit computers. FORTH, Inc. stands behind its customers with complete professional support services including custom application programming, plus polyFORTH programming courses and the FORTH, Inc. "Hotline" to help programmers learn to use polyFORTH.

For more information and a free brochure on how you can cut development cycles 4 to 10 times, contact FORTH, Inc. today. FORTH, Inc., 111 N. Sepulveda Blvd., Manhattan Beach, CA 90266. **Phone (213) 372-8493.**

FORTH, Inc.

CIRCLE NO 289

IMAGE PACKAGES

Two additions to the Series 100 product line are the Itex 100 subroutine library and the Image-Pro 100 interactive program. Itex 100 routines are callable from applications written in the C programming language and provide image-processing, graphics, and hardware-control functions. The library uses uniform naming and calling conventions to minimize the amount of information the programmer must remember. It includes more than 100 different routines that perform, for example, initialization and hardware-control functions, pixel operations, and image and look-up table archiving. The Image-Pro 100 program uses Series 100 architecture to perform real-time image processing from a menu-driven user interface. It supports use of a variety of pointing devices. A report generator allows frame composition by merging image data with graphic data from image-analysis functions. In addition, the program interfaces to most dot-matrix printers for hard-copy output of images captured, created, and/or manipulated. It includes the Halovision image editor for high-level graphics. Itex 100, \$995; Image-Pro 100, \$1495.

Imaging Technology Inc, 600 W Cummings Park, Woburn, MA 01801. Phone (617) 938-8444. TLX 948263.

Circle No 445

LISP

Using Lisp version 5.1, users can develop programs with as many as 8000 lines. This software offers more than 400 common Lisp functions, special forms, macros, and control variables. For greater speed, more than 300 of these functions are implemented in native machine code. The implementation has twice as many primitives as the previous version, including selectors, constructors, modifiers, recognizers, and comparators. It also has twice the capacity of the previous version, allowing the development of programs using as many as 512k bytes of memory. A 2-pass garbage collector reallocates data-space boundaries during program execution. This version provides infinite-precision arithmetic for all rational numbers, including floating-point numbers. It comes with a symbolic debugger, a multilevel break-and-trace facility, and a profiling facility that identifies functions critical to program efficiency. Demonstration programs included on the disk illustrate AI techniques. System requirements include PC-DOS 2.0 or higher, 128k bytes of memory, and one disk drive. \$250.

Microsoft Corp, Box 97200, Bellevue, WA 98009. Phone (206) 828-8080. TLX 328945.

Circle No 446

CD-ROM LIBRARY

The Clasix Software Library Dataplate, which includes more than 8800 IBM PC programs on one CD-ROM disk, is included free with the purchase of the Clasix Series 500 CD-ROM Datadrive. An interface card and cable for the IBM PC and PC-compatible computers are also supplied. The library features executable programs and documentation from the PC Sig Library of public-domain and user-supplied software. An optional audio card allows the Datadrive to play compact audio disks and function alternately as the PC user's data-storage device or as a high-fidelity audio system component. Series 500 CD-ROM Datadrive plus software library, $1595; audio card, $149.

Reference Technology Inc, 1832 N 55th St, Boulder, CO 80301. Phone (800) 225-2749; in CO, (800) 826-7873.

Circle No 447

TURBO PASCAL TOOLS

Two packages of scientific programming tools, the IPC-TP-006 and the IPC-TP-007/008, provide the Turbo Pascal and Turbo-87 Pascal programmer with a variety of routines for applications programs. Both packages run on IBM PC, PC/XT, PC/AT, and compatible computers. The general science and engineering package, IPC-TP-006, includes procedures for general statistics, multiple regression, curve fitting, integration, FFTs, file transfers to and from Lotus 1-2-3, solving simultaneous equations, matrix math, linear programming, and graphic display. The Turbo Pascal data-acquisition package, IPC-TP-007, operates with the IBM Data Acquisition Adapter and the Cyborg Isaac 41I and 91I hardware; the -008 version of this package operates with MetraByte Dash-8 and Dash-16 hardware. These data-acquisition packages include procedures for analog and digital input and output, thermocouple linearization, data logging, process control, and real-time graphics. Source code is provided for these programs. IPC-TP-006, $69.95; IPC-TP-007/8, $94.95.

Quinn-Curtis, Box 10, Newton Centre, MA 02159. Phone (617) 969-9343.

Circle No 448

ENHANCED COMPILER

RM/Fortran V.2 is available for IBM PC/ATs and compatibles running under Xenix as well as for the Altos 2086. According to the manufacturer, it's the only program for personal computers that is a full Fortran-77, GSA-certified compiler that's error-free to the highest possible level. It also carries VAX, VS, and Fortran-66 language extensions frequently used in mainframe applications. The compiler boasts enhancements in execution speed, language features, ease-of-use upgrades, and new utilities. The Xenix implementation directly addresses more memory than DOS versions: Under Xenix, total program size is limited only by the computer's available memory. $750.

Ryan-McFarland Corp, 609 Deep Valley Dr, Rolling Hills Estates, CA 90274. Phone (213) 541-4828. TLX 294253.

Circle No 449

DATA SIMULATOR

Picon, an on-line, real-time expert system for industrial-automation applications, now offers simulation capabilities. These capabilities enable users to simulate operating data to test their system's response to process upsets as well as standard operating conditions. In addition, these capabilities can help new operators learn their jobs prior to plant construction. The system's simulator supplies sensor values to

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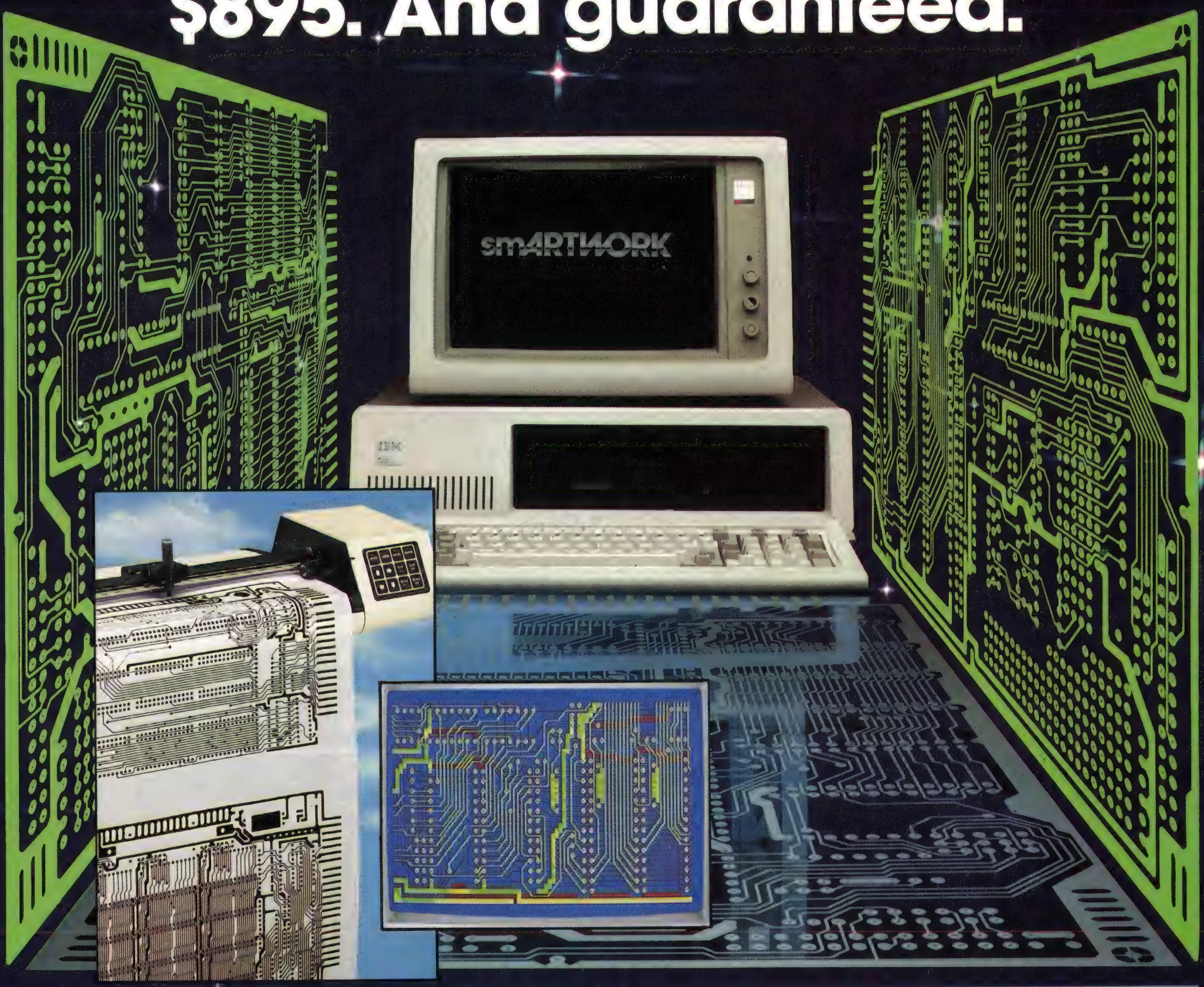

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- ☐ IBM Personal Computer, XT, or AT with 320K RAM, 2 disk drives, and DOS Version 2.0 or later
- ☐ IBM Color/Graphics Adapter with RGB color or black-and-white monitor
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- ☐ Houston Instrument DMP-41 pen-and-ink plotter
- ☐ Microsoft Mouse (optional)

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CIRCLE NO 290

the inference engine in lieu of data from the real process or factory. It can solve sets of difference equations, which allows it to realistically portray the changing conditions of a process over time. The user can switch the input to the inference engine from actual plant data to simulation and back again to allow incremental testing of the system's response to various scenarios. After the process is completed, the system responds with appropriate diagnoses or operator messages. The system runs on the manufacturer's Lambda Plus multiprocessor and costs $60,000.

Lisp Machine Inc, 6 Tech Dr, Andover, MA 01810. Phone (617) 689-3554.

Circle No 450

VRTX FOR VME

This company has ported its VRTX real-time operating system to Motorola's VMEmodule board family. The MVME device support packages allow users of three VMEmodule units—the MC68010-based MVME117 and MC68020-based MVME130 single-board microcomputers and the MVM320 Winchester/floppy-disk controller—to interface the boards' hardware devices easily to the VRTX/OS. Because each MVME device support package is supplied in the form of source-code listings, users can modify variables, such as baud rate, to fit specific applications. The MVME117 and MVME130 packages provide driver support for onboard devices such as the MC68881 floating-point coprocessor, RS-232C ports, 8-bit parallel ports, the SCSI bus, the MC68B40 programmable timer, and the 8-bit software-readable front-panel switch. MVME117 and MVME130 device support packages, $500 each; MVME320 package, $1000.

Hunter & Ready, Box 11803, Palo Alto, CA 94306. Phone (415) 326-2950. TLX 278835.

Circle No 451

IMAGE PROCESSING

The RTI-Station is an integrated digitizing, storing, and processing system for IBM PCs and PC-compatible systems. It digitizes a high-resolution (512×512-pixel, 8-plane) video signal in 1/30th of a second from an RS-170, RS-330, RS-343, or CCIR source. You can connect as many as four video sources to the processing system. In addition, the system's signal-conditioning hardware permits connections to VCRs and cameras. The system performs automatic input dc restoration; gain/level controls are programmable. Four programmable 256×8-bit transformation tables allow pre-processing of the input signal. RTI-Station's imaging-software library provides a driver interface, basic board-level control, high-level imaging algorithms for image enhancement, feature extraction, object recognition, and comprehensive board diagnostics. $10,000 to $23,500.

Recognition Technology Inc, 335 Fiske St, Holliston, MA 01746. Phone (617) 429-7804.

Circle No 452

FORTH TOOLS

An enhanced pf8086/MSD package for PolyForth programming operates under MS-DOS but provides multiuser, multitasking capabilities not available in standard MS-DOS systems. Included are an integrated graphics package and screen-oriented editor that runs with any standard IBM color monitor. The standard math package is supplemented by one that uses the 8087 math coprocessor and allows you to perform 32- and 64-bit floating-point math, matrix arithmetic, and trigonometric, log, and exponential functions. The package comes in several levels. Level 3 includes the multiuser, multitasking operating system, a compiler, an assembler, a high-level interpreter, a string editor, routines for database support, disk and print utilities, and source


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code for the elective utilities. Level 4 has all the facilities of Level 3 plus a target compiler and source code for the entire system. Level 3, $600; Level 4, $3200.

Forth Inc, 111 N Sepulveda Blvd, Manhattan Beach, CA 90266. Phone (213) 372-8493. TLX 275182.

Circle No 453

Z80 CROSSASSEMBLER

The AX Z-80 absolute crossassembler and the RX Z-80 relocatable crossassembler both run on the IBM PC and compatible computers. The AX Z-80 absolute crossassembler translates an assembly source file into a downloadable object file with absolute addresses in Intel hex format. The RX Z-80 relocatable version translates an assembly source file into a relocatable file, which you can then link with other relocatable files (by using the linker included in the package) to form a downloadable object file in Intel hex format. Both crossassemblers feature pseudo-ops and conditional assembly and include descriptive error messages and cross-reference tables. One-time fee for AX Z-80, $250; for RX-Z80 with linker, $400.

United States Software Corp, 5470 NW Innisbrook Pl, Portland, OR 97229. Phone (503) 645-5043. TLX 4993875.

Circle No 454

AI TOOLS

The Lisp Toolkit runs on any VAX, MicroVAX II, VAXstation II, or DEC AI Workstation that's configured to run VAX Lisp (version 1.2 or a later version). It also works in conjunction with Inference Corp's Automated Reasoning Tool (Art). This set of development tools includes five main modules: The FMS Module is a fourth-generation form- and menu-display package layered on VAX FMS. The GKS Module allows the control, use, and generation of device-independent imaging and graphics from VAX Lisp or Art. The RDB Module allows the tight integration of traditional database technology with AI technology. The CMS/MMS Module extends DEC/CMS and DEC/MMS to permit application maintenance of VAX Lisp- and Art-based systems. The DECnet Module provides a VAX Lisp-based distributed communications environment for building cooperating expert systems or any other VAX Lisp-based distributed applications. License for VAX 8600, $24,000; for 78/785, $15,000; for VAX 750, $8000; for DEC AI Workstation, $6000.

Composition Systems Inc, 570 Taxter Rd, Elmsford, NY 10523. Phone (914) 592-3600.

Circle No 455

PL/I COMPILER

The PL/I compiler for Prime Series 50 superminicomputers meets the requirements of the ANSI X3.53-1976 and ISO 6160 standards for the PL/I language. It also contains extensions, such as Select and Leave statements, to provide functional compatibility with IBM PL/I. The compiler is upward compatible with the extended version of PL/I Subset G offered by the company. Both compilers use the same run-time library, so that third-party programs compiled under either of them can be run without the presence of the compiler. Both compilers are compatible with the the company's Interactive Source Debugger and use the same interface to the PRIMOS operating system. For Prime office systems, $4000; for Prime computer-room systems, $7000.

Prime Computer Inc, Prime Park, Natick, MA 01760. Phone (617) 655-8000.

Circle No 456

PROCESS SIMULATOR

The Chemcad integrated PC software system provides process simulation and 2-D CAD. You can prepare process designs, quickly analyze design alternatives, predict the effects of changes on plant operating conditions, optimize energy consumption, and eliminate bottlenecks and increase throughput. The package can simulate flowsheets containing as many as 100 streams and 50 pieces of equipment, and it has 16 built-in equipment modules capable of modeling virtually all process plants. The same program that you use to perform the simulation allows you to produce the process flow diagram (PFD); you choose which calculated results appear on the PFD. You can obtain hard copy using an HP 7400 Series plotter or an Apple laser-jet printer. The program runs on an IBM PC or equivalent with 64k bytes of RAM, a hard disk, an Intel math coprocessor, and an IBM enhanced color-graphics adapter. $7350.

Coade, Div of International Thomson Information Inc, 8550 Katy Freeway, Suite 122, Houston, TX 77024. Phone (800) 231-0732; in TX, (713) 973-9060.

Circle No 457

SCHEMATIC CAPTURE

Circuit Design Mate schematic-capture program allows editing of schematics in much the same way that a word processor handles text. The menu-driven, self-prompting program can retrieve often-used parts from libraries of user-created components or from the library of standard TTL parts that is supplied with the package. Files can contain multiple pages of schematics, and you can print schematics in A, B, or 11×14-in. sizes. The program requires an IBM PC, PC/XT, PC/AT or compatible system with 256k bytes of RAM; a 640×200-pixel IBM-compatible graphics card; two double-sided disk drives or one floppy-disk drive and one hard-disk drive; an Epson or compatible dot-matrix printer with graphics capability; and PC-DOS or MS-DOS 2.0 or higher. $295.

Midwest Micro-Tek Inc, Box 29376, Brooklyn Center, MN 55429. Phone (612) 560-6530.

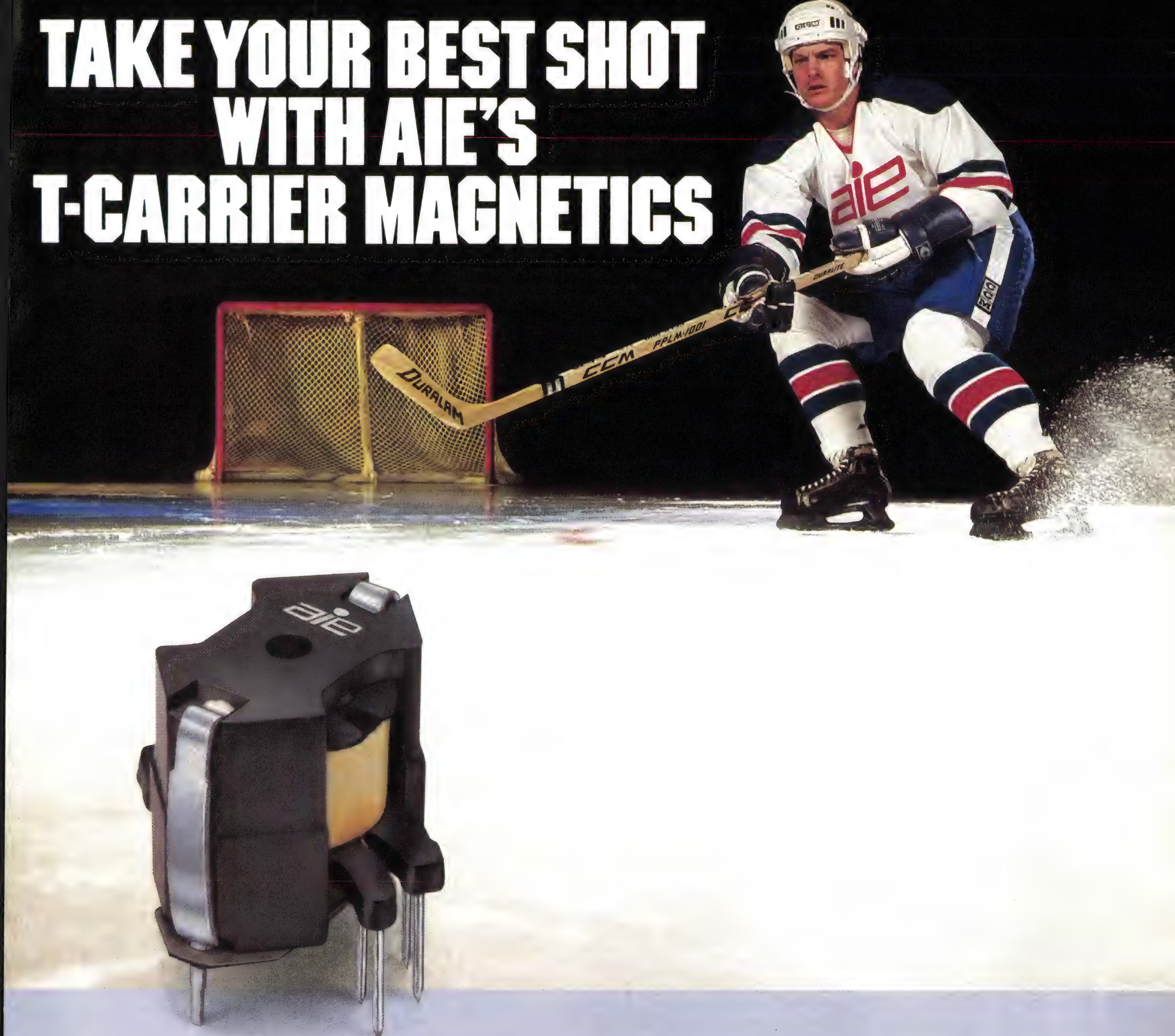
Circle No 458

BASIC COMPILER

The BC 204 Basic compiler is the first compiler available for HP Basic, version 4.0, according to this manufacturer. It's compatible with HP 9000 Series 200/300 workstations. Compiled programs operate directly with the manufacturer's FP 200 or FP 210 floating-point coprocessors as well as the HP 98635 floating-point coprocessor. $880.

Infotek Systems, 1400 N Baxter St, Anaheim, CA 92806. Phone (714) 956-9300.

Circle No 459



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CIRCLE NO 292

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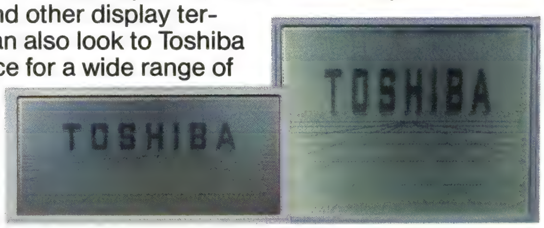
These versatile LCDs are ideally suited for applications as displays for personal computers, POS terminals, portable word processors and other display terminals. You can also look to Toshiba with confidence for a wide range of sizes and display capacity to suit your LCD requirements.



TLC-363B *TLC-402*

Specifications

		TLC-402	TLC-363B
Display			
Number of Characters		80×25 (2,000 characters)	80×25 (2,000 characters)
Dot Format		8×8, alpha-numeric	8×8, alpha-numeric
Overall Dimensions (W × H × D)		274.8×240.6×17.0 mm	275.0×126.0×15.0 mm
Maximum Ratings			
Storage Temperature		−20° ~ 70° C	−20° ~ 70° C
Operating Temperature		0° ~ 50° C	0° ~ 50° C
Supply Voltage	V_{DD}	7 V	7 V
	$V_{DD} - V_{EE}$	20 V	20 V
Input Voltage		$0 \leq V_{IN} \leq V_{DD}$	$V_{SS} \leq V_{IN} \leq V_{DD}$
Recommended Operating Conditions			
Supply Voltage	V_{DD}	5±0.25V	5±0.25V
	V_{EE}	−11±3V Var.	−11±3V Var.
Input Voltage	High	V_{DD} − 0.5V min.	V_{DD} − 0.5V min.
	Low	0.5V max.	0.5V max.
Typical Characteristics (25°C)			
Response Time	Turn ON	300 ms	300 ms
	Turn OFF	300 ms	300 ms
Contrast Ratio		3	3
Viewing Angle		15 – 35 degrees	15 – 35 degrees

Design and specifications are subject to change without notice.

TOSHIBA

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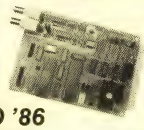

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AMS
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(603)882-1447

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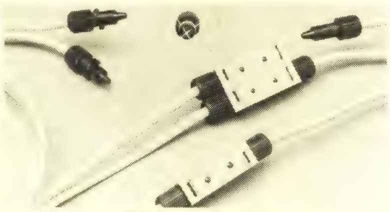

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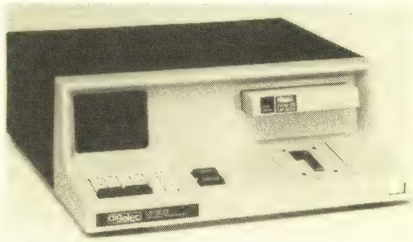

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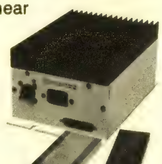

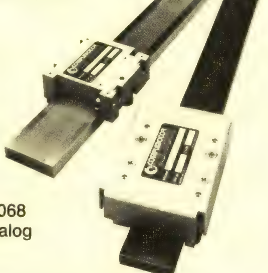

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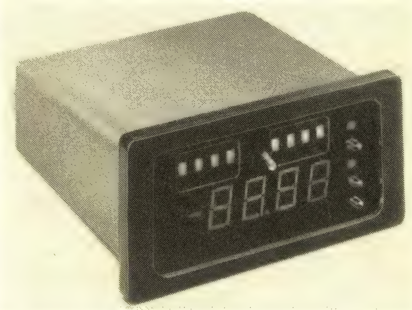
CIRCLE NO 242

UNIVERSAL UP/DOWN COUNTER



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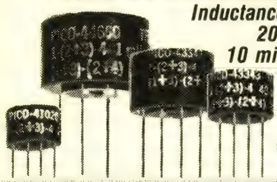

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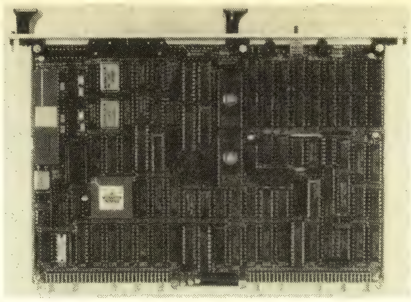

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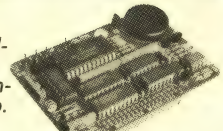

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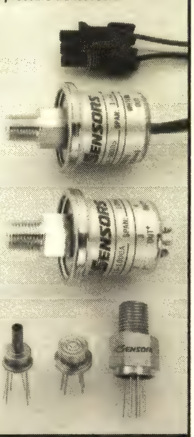

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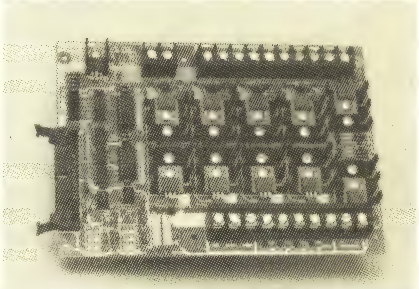

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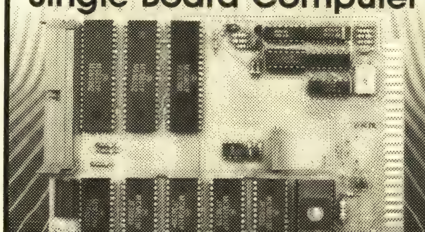

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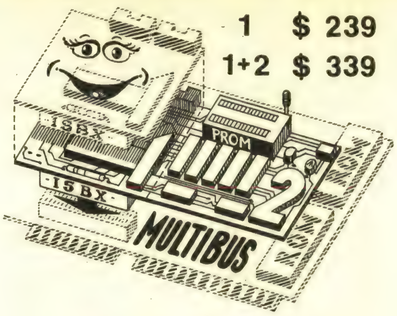

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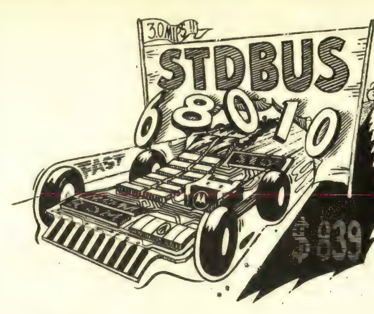

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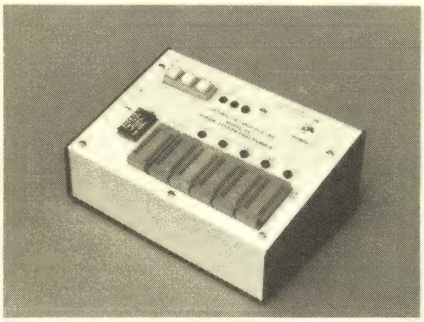

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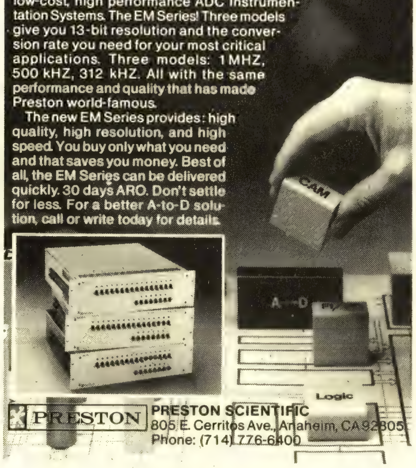

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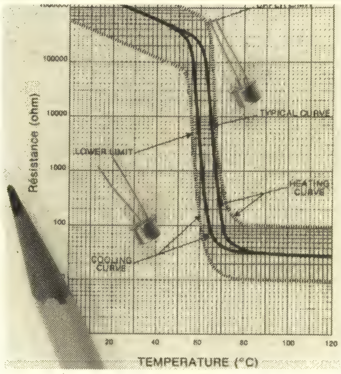

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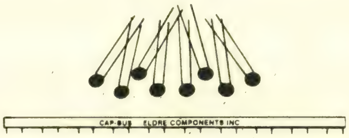

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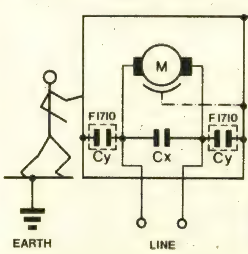
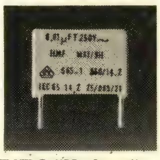


F 1710



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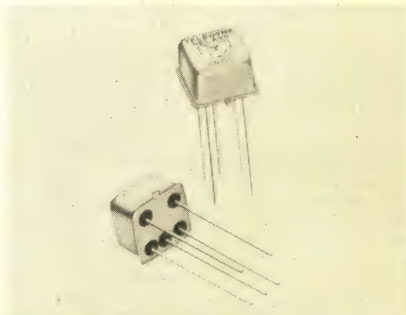

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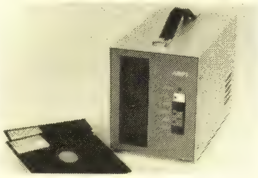

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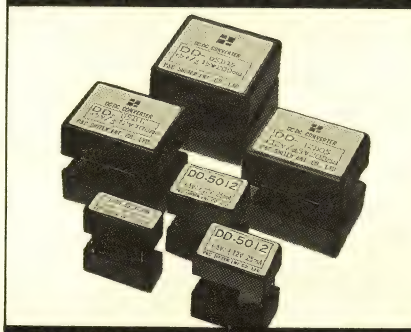

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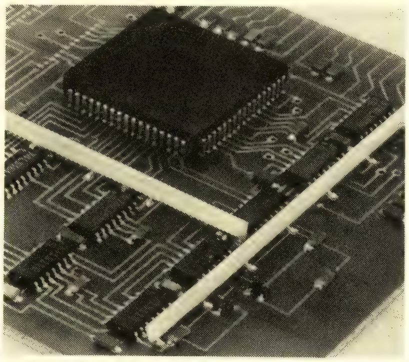

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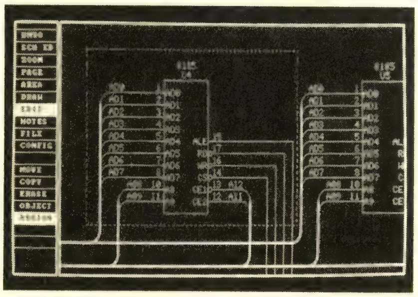

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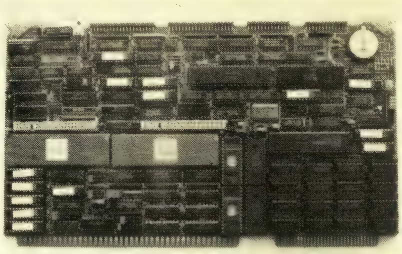

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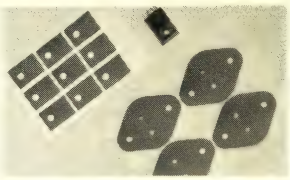

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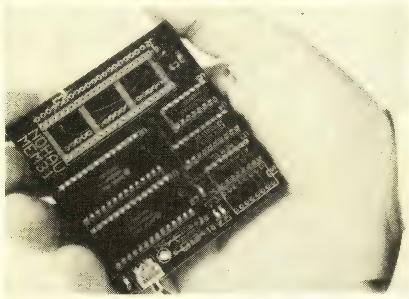

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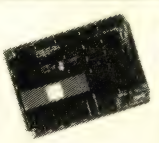

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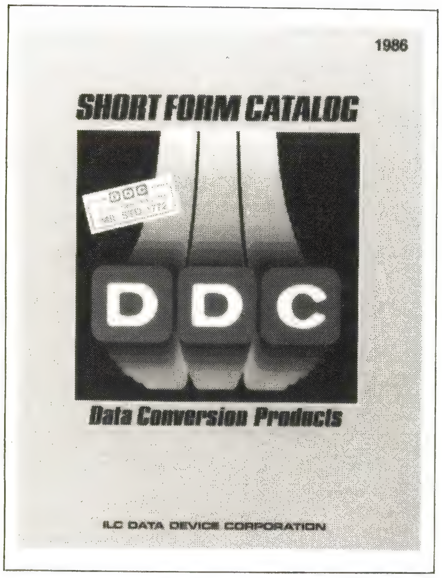

Catalog depicts data converters, -1553 products

This 1986 8-pg short-form catalog describes more than 100 of the manufacturer's products, including numerous new devices. It provides specs and technical data for databus products, A/D and D/A converters, synchro-to-digital and digital-to-synchro converters, S/H and T/H amplifiers, synchro and resolver instruments, and MIL-STD-1553 components. The booklet also depicts units providing special functions such as control transformers, a synchro booster amplifier, and Inductosyn-to-digital converters. In addition, it describes the company's MIL-STD-1772-qualified facilities.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716.

Circle No 460

App note explains remote temperature transducer

This 4-pg application note concentrates on minimizing the influence of noise in remote-temperature-measurement circuits. It outlines how to build a remote temperature-to-current transducer with a −55 to +100°C range and a 100-mV/°C output voltage using the AD590 linear current-output temperature transducer. The publication treats types of noise, initial noise effects, elements of noise, RF noise, and shielding to eliminate electrostatic noise. Sixteen accompanying diagrams include graphs of RF noise, correct shielding, mutual inductance noise, and bypass capacitors to reduce RF noise effects.

Analog Devices, Literature Ctr, 70 Shawmut Rd, Canton, MA 02021.

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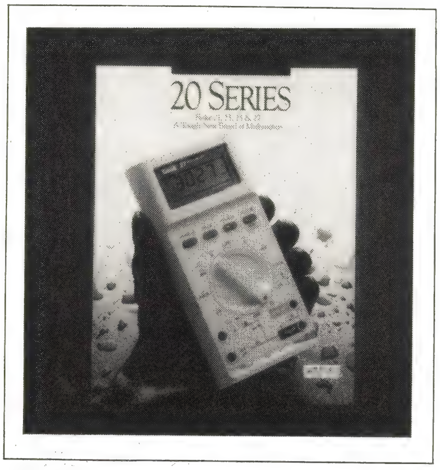


Digital multimeters described

This 8-pg color brochure details Series 20 ruggedized digital multimeters and explains the design and construction of the instruments. It also includes information on typical applications, a specification table, and a listing of accessories for the meters.

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206.

Circle No 462

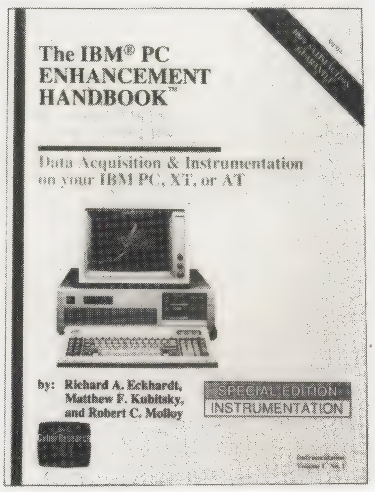
Guide lists semiconductor and IC products

The *Designer Selection Guide (# R15)* describes the company's semiconductor and IC products. It details representative items in each product family, and one section details packaging options. Among the products covered are microprocessors, microcontrollers, peripheral devices, dynamic and static RAMs, and EPROMs. Also included are gate arrays, coder/decoders, bipolar and logic families, and linear ICs, as well as gate turn-off modules, power

MOSFETs, and optoelectronic devices.

Hitachi America Ltd, Semiconductor & IC Div, 2210 O'Toole Ave, San Jose, CA 95131.

Circle No 463



Handbook features PC-based data-acquisition products

The data-acquisition and instrumentation special edition of *The IBM PC Enhancement Handbook for Scientists and Engineers* includes tutorial information and descriptions of products and systems for data acquisition, instrumentation control, and process control based on the IBM PC, PC/XT, and PC/AT. The instrumentation section of the handbook covers such topics as controlling instruments through use of the IEEE-488 bus or through serial communications (RS-232C, -422, and -485). It also provides descriptions of hardware and software products that allow you to convert the IBM PC to various laboratory instruments. The data-acquisitions section of the handbook includes information on systems and components for both local and remote applications. $9.95.

CyberResearch Inc, Box 9565, New Haven, CT 06536.

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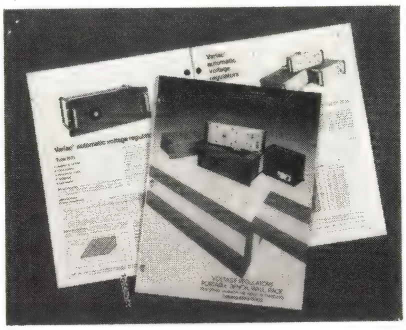
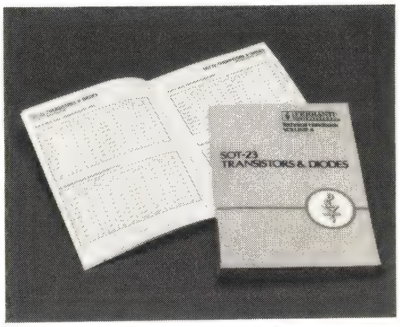


Voltage-regulator catalog covers five categories

This voltage-regulator catalog provides specs, schematics, and applications information on the company's regulators. The multicolor publication details products in portable, bench, wall-, rack-, and panel-mount versions. In addition, it describes how the standard units can be altered and provides information on custom items.

Technipower, Box 222, Commerce Park, Danbury, CT 06810.

Circle No 465



SOT-23 parts highlighted

This 270-pg technical handbook, which covers the manufacturer's SOT-23 transistors and diodes, provides both general information on the SOT-23 package and product-specific information. The technical-data section provides fully characterized data on more than 140 device types. The handbook also includes a product index of JEDEC and Pro-Electron types, listing commercial and quality-assured parts.

Short-form selector tables that group devices by application are provided. A section on quality and reliability and a description of tape-and-reel specifications conclude the treatment.

Ferranti Electric, Semiconductor Div, 87 Modular Ave, Commack, NY 11725.

Circle No 466

Handbook offers 102 linear-IC ideas

Circuit Ideas for Linear ICs, a 34-pg handbook, offers 102 circuits based on linear ICs and MOSFETs. The handbook is divided into nine sections of ideas that can be applied to industrial and consumer equipment. Included are sections on timing, measurement, modulation, power control, data conversion, communications, alarm monitoring, and other topics. A schematic illustrates each circuit, and a description of the circuit's function is provided.

RCA Solid State Div, Box 2900, Somerville, NJ 08876.

Circle No 467

Guide aids in network planning

This planning and international-standards guide aids designers who use the manufacturer's local- and wide-area network products. The guide features planning information on Primenet, a distributed networking facility that provides local- and wide-area networking for all of the company's systems. Also provided is information on Ringnet, a local-area network, and guidelines on international LAN standards. The 16-pg guide is illustrated with schematics and charts.

Prime Computer Inc, Sales Leads Group, M/S 15-60, Prime Park, Natick, MA 01760.

Circle No 468

Guide lists southern California businesses

Details of more than 2700 high-tech companies are included in the first edition of *Rich's High-Tech Business Guide to Southern California*. The guide, a sister publication to the Silicon Valley edition, provides the names of key executives, addresses, phone numbers, year established, product descriptions, and number of employees. Also included are more than 20 maps of areas between San Diego and Santa Barbara. $98.50 includes shipping; in CA, add $6.65 sales tax.

Business Directories Inc, 101 First St, Suite 426, Los Altos, CA 94022.

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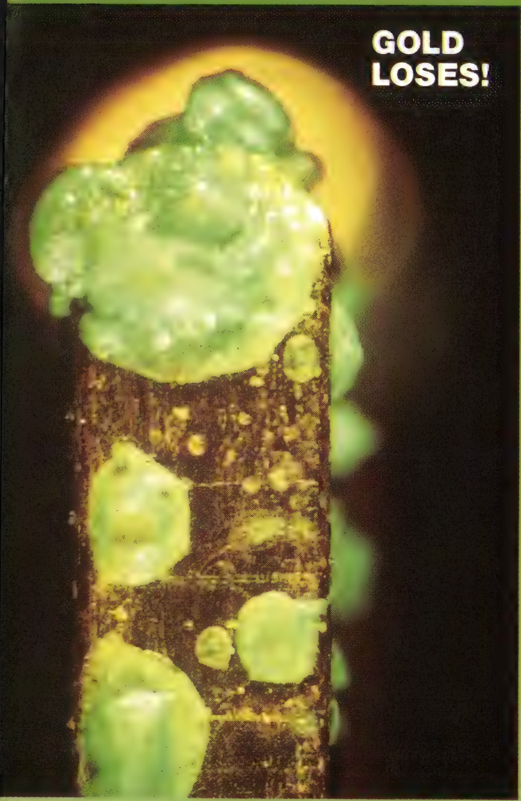

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of two plated header pins after 1-hour nitric acid porosity test.

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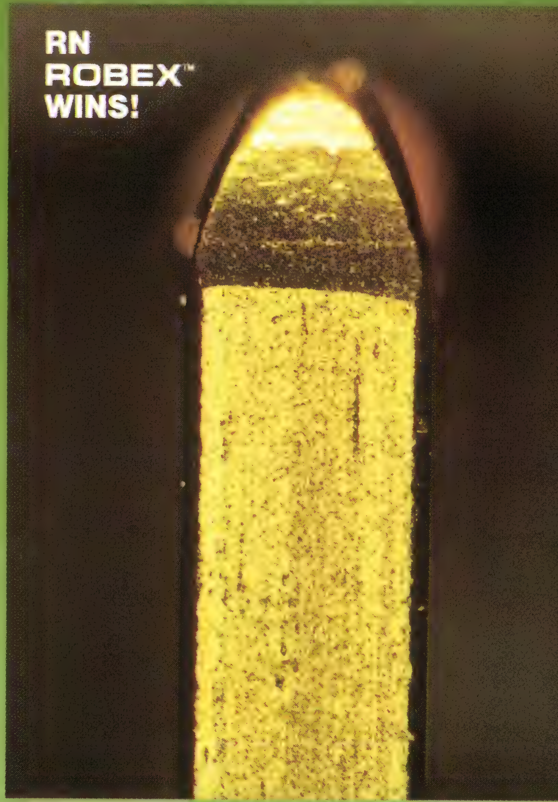

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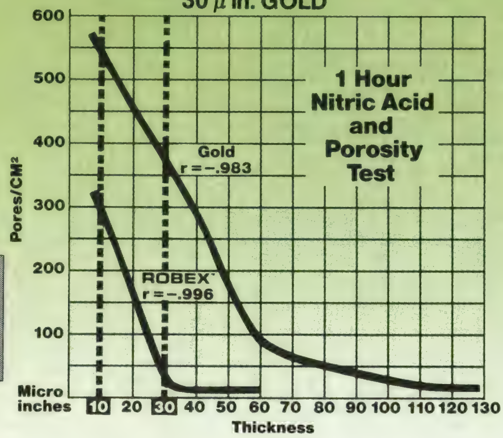

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Telecommunications Integrated Circuits (#659). 157 pgs; $1650; International Resource Development Inc, 6 Prowitt St, Norwalk, CT 06855.

This report covers more than 50 major competitors in the communications-IC market, including Japanese and European chip manufacturers. The report, which predicts a 30% growth rate for this market during the rest of the decade, analyzes technologies such as gallium arsenide and silicon compilation and also takes in to account Integrated Services Digital Networks (ISDN). The satellite- and military-equipment markets are already using chips designed in GaAs, but this report speculates that applications of this technology are just beginning to surface.

Strategic Issues in Automated Production: The Challenge of Robotics and Computer Integrated Manufacturing, by Tony Owen. 95 pgs; $50; Manufacturing Technology Press Inc, Box 206, Lake Geneva, WI 53147.

With an assessment of the state of the art in computer-integrated manufacturing, this report discusses the economic future of robotics and computer-integrated manufacturing based on their strengths and weaknesses. The report analyzes worldwide industrial trends and their impact on current and future computer-integrated manufacturing. It includes information on automation, robot technology, vision systems, CAD/CAM, and the economics of the market.

Digital Signal Processor (DSP) Market Report. $500; Business Development Group Inc, Box 3044, Stanford, CA 94305.

This report offers a review of the DSP market, products, competition, and technology, giving market forecasts and estimated competitive market share for the period between 1985 to 1990. It discusses advances in chip technology that, combined with the rising density and speed of VLSI circuits, is creating a new generation of digital signal processors. The success of the DSP market is based on the significant benefits and cost performance that these products provide in a wide range of real-time applications. The report places the products in seven categories: single-chip processors, specialized circuits, building-block circuits, data-flow and systolic-array devices, chipsets, boards, and development systems.

Multiuser μC Systems Market Through 1990. $2450; Venture Development Corp, Box 9000, Natick, MA 01760.

This report examines the US market for multiuser μCs and LAN-based systems through 1990. It discusses strategic guidelines and recommendations for qualifying OEMs and VARs, how to select vertical markets, and how to develop an effective promotional marketing program. Results are based on a nationwide survey of OEMs/VARs and corporate users of multiuser systems, in which questions about μC-feature preferences, marketing and service requirements, vertical market applications, and future purchasing plans were asked. Profiles and competitive positions of 50 major industry participants are included.

Connector Industry Forecast II. 1600 pgs; $15,000; Gnostic Concepts Inc, 951 Mariner's Island Blvd, Suite 300, San Mateo, CA 94404.

This report focuses on US consumption of 85 distinct types of connectors, along with future market and technological directions for each connector type. Connector consumption is divided into 51 categories of electrical/industrial and electronic equipment producers with company profiles of 67 US and foreign connector and IC-socket manufacturers. The report describes the technological outlook for high-density designs, the impact of surface-mount technology, connector applications for EMI/RFI, and new materials used in manufacturing connectors. A fiber-optics update is also included, along with a 2-volume database, which presents value, quantity, price, and input/output coefficients by connector type for the 1984 to 1990 forecast period.

Optical Memory's Impact on Magnetic Storage and Computer Systems Architecture. $1250; Electronic Trend Publications, 10080 N Wolfe Rd, Suite 372, Cupertino, CA 95014.

This report focuses on the development of optical data-storage technology and examines trends in CD ROM, write-once, read-many optical disk players and systems, and various types of erasable optical-disk products. The report reviews the problems that each optical technology must face and solve in order to become established; it also discusses the issues that have impeded the technology's growth in general. The study investigates current optical applications that represent attractive alternatives to paper-based and magnetic storage-based systems already in use. In addition, the key manufacturers who are shaping the market are discussed.

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CIRCLE NO 297

NEW BOOKS

The Professional Microcomputer Handbook, by Ivan Flores. 881 pgs; $49.95; Van Nostrand Reinhold Co Inc, New York, NY, 1985.

After an overview of microcomputers, this book presents a tutorial on four aspects of the subject: hardware, operating systems, programming, and application packages. Each section defines technical terms, explains how various mechanisms and programs work, and compares competitors' features. All types of personal computers are catalogued according to the size of their memory, their software, and their control systems. The computers' printed-circuit boards are also detailed. Further, design and coding with detailed instruction about MBasic and Basica, Pascal and PL/I are included. A general discussion on operating systems is supplemented by specific information on CP/M, PC-DOS, and MS-DOS.

Inside the Technical Consulting Business: Launching and Building Your Independent Practice, by Harvey Kaye. $19.95; John Wiley & Sons Inc, New York, NY, 1986.

This book defines consulting and describes what you must do to become a good technical consultant. The author explains how you can use your abilities and skills to be a successful consultant, and he gives marketing tips to assist you to that end. A self-appraisal quiz is included to help you decide if consulting is the right career for you.

Patenting and Marketing Your Invention, by Bernard Rivkin. $34.95; Van Nostrand Reinhold Co Inc, New York, NY, 1986.

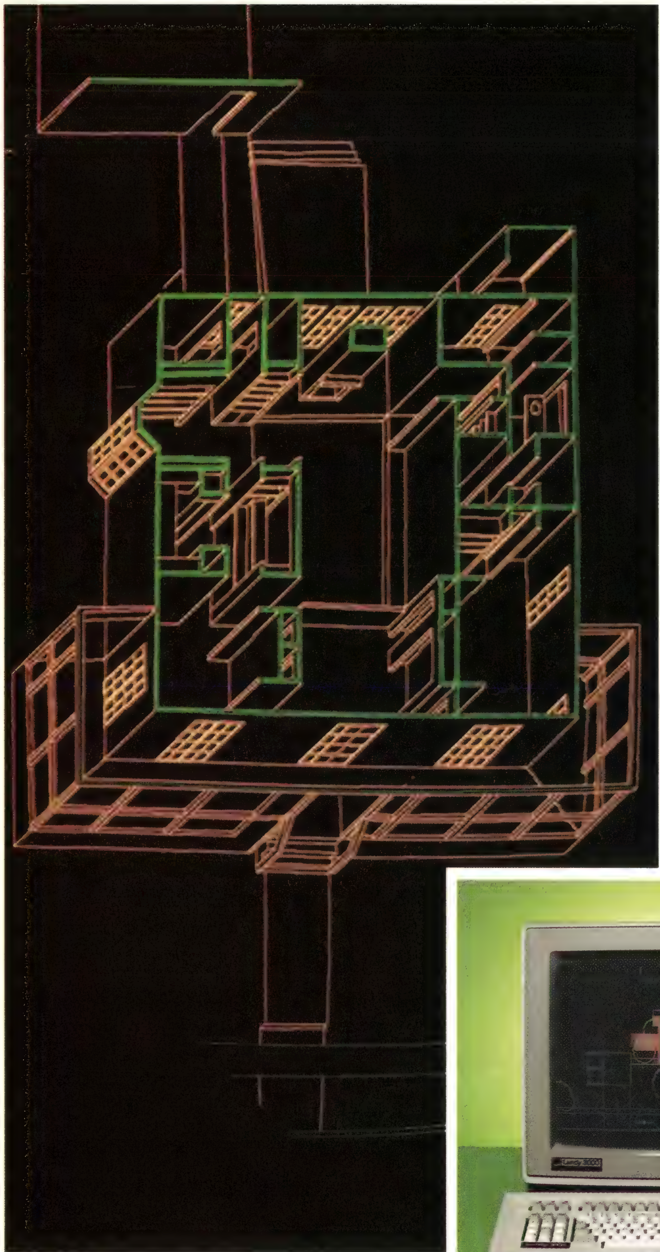
This guide provides the legal and business information that inventors need to know in order to protect their products. It contains facts on the legislation governing the protection of ideas, including the Presidential order of November 1984; fee schedules for patents and trademarks are listed. Other topics include patent searches, selecting patent attorneys and agents, the licensing and sale of patents, and guidelines on how to get a patent for your computer software. It discusses financing and developing an invention, including information on venture capital, research and development tax, and R&D limited partnerships. An appendix lists useful sources and services, completed patents, and trademarks.

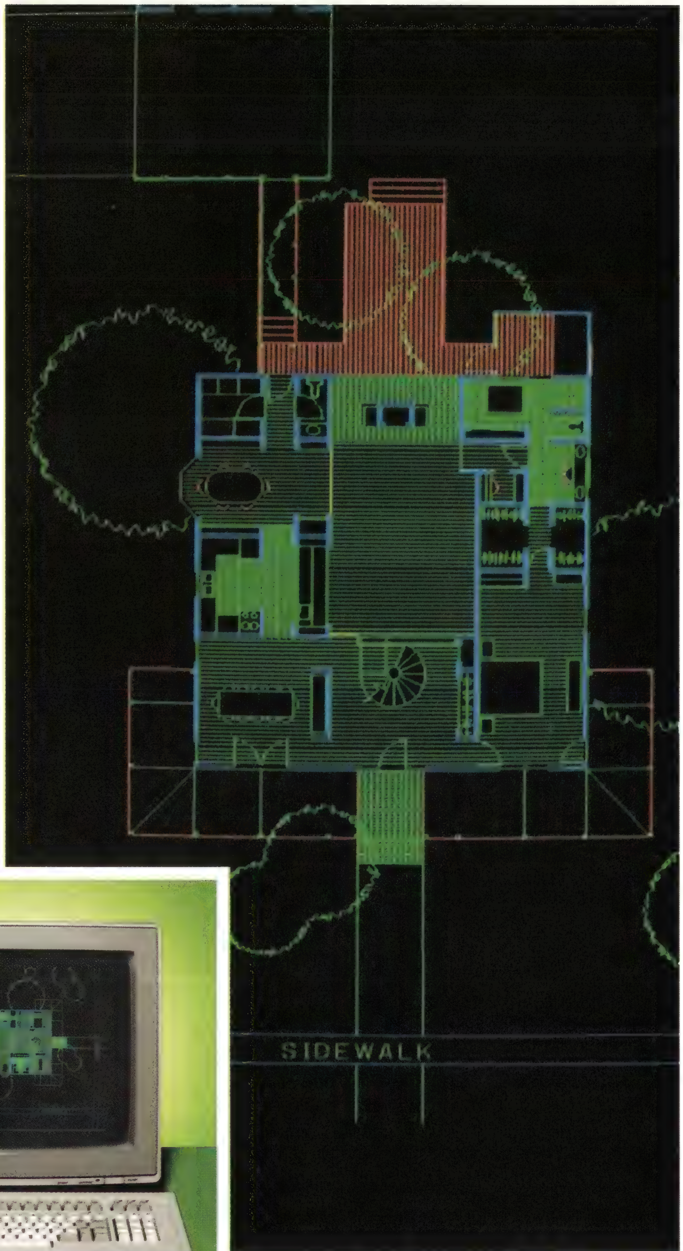
The C Primer, by Les Hancock and Morris Krieger. 2nd ed; 303 pgs; $17.95; Byte Books/McGraw-Hill, New York, NY, 1986.

This book examines the various features of the C language, demonstrates how to read and write programs written in this computer language, and shows how C can be used as an alternative to other high-level languages. This second edition contains information on bit fields and masks, functions that operate on single bits, and the development of a line-by-line sorting program. The book also contains extended treatment of subjects such as pointers, the C preprocessor, structures and unions, and the file I/O. Included are 129 complete program examples in C.

Contemporary Electronics Circuits Deskbook, edited by Harry L Helms. 253 pgs; $29.95; McGraw-Hill Book Co, New York, NY, 1986.

This reference guide is a compilation of circuit designs and applications from recent electronics magazines, application notes, and data books. Each circuit diagram was reproduced directly from the original source. Topics examined include





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International CAD/CAM Software Directory, edited by Philip C Flora. 180 pgs; $35; Technical DataBase Corp, Conroe, TX, 1986.

This directory provides a detailed technical description of manufacturing and engineering graphics packages. Some of the applications covered include data acquisition, engineering calculation, inventory, computer-aided design, manufacturing management, operating efficiency, and computer-aided manufacturing. Each listing includes information such as the required hardware and software environment, minimum memory requirement, list price, documentation provided, availability of updates and source code, warranty policy, technical support provided, and delivery time. A glossary of terms and two indexes, one by application and one by vendor, are also included.

Patent It Yourself, by David Pressman. 421 pgs; $24.95; Nolo Press, Berkeley, CA 94710, 1985.

This step-by-step guide shows you how to obtain an effective US patent. It includes an overview and comparison of patent, copyright, trademark, and trade secret laws. The book also contains information on how to assess the commercial potential of an invention, the specific criteria used by the US Patent Office for granting a patent, and how to draft and file a complete patent application. This book will also tell you how to enforce and maintain your patent.

Software Engineering Handbook, by the staff of General Electric Co. 224 pgs; $59.50; McGraw-Hill, 1985.

How to develop software systematically, document it during development, and improve its quality are some the topics of this book. It contains advice on how to plan, estimate, budget, and schedule software engineering, and how to apply up-to-date techniques to each phase of the process. Topics covered include defining the scope of a project, analyzing the functions and performance requirements, developing both an architectural representation and a procedural representation of the software, and using a programming language to transform the design representation into a functionally equivalent program. The book also outlines how to test software for latent defects and how to validate the software against the requirements. A section on small projects explains how to abbreviate some steps in the engineering process and shorten the necessary documentation for smaller projects.

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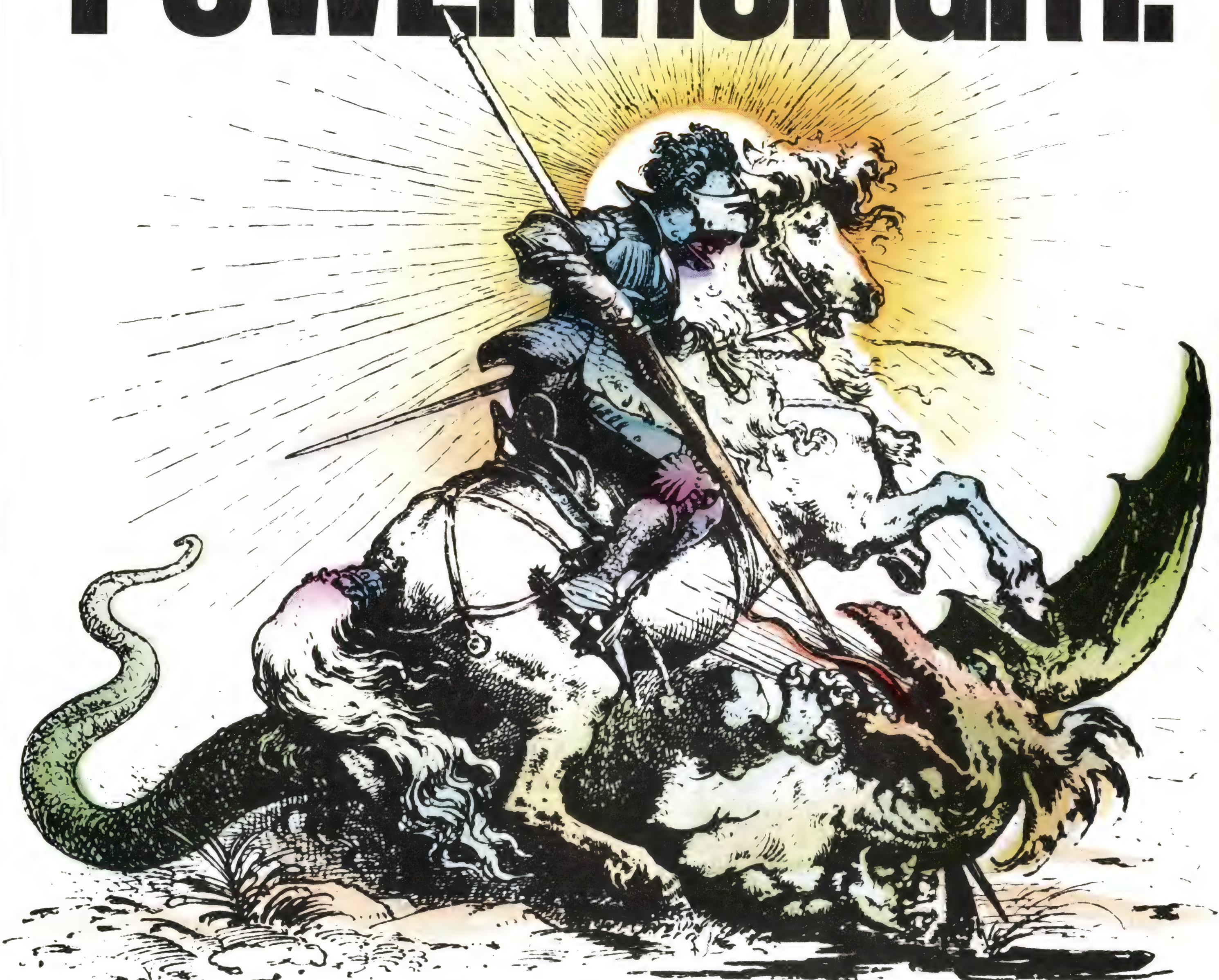


CIRCLE NO 300

Employees find their pension benefits often add up to unkept promises

Deborah Asbrand, *Staff Editor*

At first glance, private businesses' pension funds appear to be overflowing with money. The assets of private pension funds in 1984 totalled nearly $1 trillion, according to the Employee Benefit Research Institute, a Washington, DC, research organization. And new money continues to stream into the funds at a staggering rate: The Department of Commerce's Bureau of Economic Analysis estimates that, in 1984 alone, companies contributed $68 billion to their employees' pension funds.

With billions of dollars flowing into pension coffers each year, it would seem that all employees who qualify for a pension would be well provided for. Yet nothing could be further from the truth. Tearing at the fabric of conventional retirement plans are social, economic, and political changes that have strained the pension system to the point where it no longer meets the needs of many workers.

The traditional retirement plans still in effect at many companies have become dusty relics, reflecting the work habits of a work force that has long since changed. Structured to reward long-time employment with one company, the plans have proven inadequate in providing a comfortable retirement income for employees who work for several employers throughout their careers.

Conventional retirement plans credit employees with a percentage of their salary for each year they work for the company. To take a simple example, employees in a pension plan might be credited with 1½% of their salaries for each year they worked for their company. An

employee who worked for an employer for 40 years consequently receives a pension that equals 60% of one year's average salary. Typical pension plans are actually more complex, factoring in what are referred to as "career averages" or "final averages" to determine the benefit.

When workers spent their entire careers with one company, they were able to fulfill their employers' vesting requirements to qualify for a pension. But employees today rarely spend their careers working for one employer. And even if they are fortunate enough to work for one employer long enough to qualify for a pension or become vested, many workers find that inflation has eaten away at the money that was set aside for them, leaving them with a benefit much smaller than they had anticipated. In addition, improved health care has extended average life spans so that more people now live to retirement age and beyond. A longer life span means a pension that's effectively smaller by being distributed over more years.

Although private businesses are not required to provide pension plans for their employees, most do offer some kind of retirement benefits. To take the electronics industry as an example, more than 87% of respondents to the IEEE 1985 US Member Salary and Fringe Benefit Survey said they worked for employers who provide pension coverage. Companies keep a watchful eye on the balance sheets, however, and are usually reluctant to bear the costs incurred by expanding their retirement plans to meet changing conditions. As a result, legislative reforms that would aid workers are strongly opposed by industry lobbying groups.

Business groups view their voluntary participation in a pension plan as laudable, says Ann Moss, deputy director of the Pension Rights Center in Washington, DC. Consequently, they take a dim view of any federal attempts to regulate private pension funds. "If the government forces them to make too many changes that they consider expensive," says Moss, they threaten to eliminate their plans.

Widespread corporate abuses

Inflation, improved health care, and frequent changes in employment are not the only factors that conspire to erode workers' pension benefits. Long a target for corruption, wealthy pension funds have become the subject of widespread corporate abuses in recent years, to the detriment of many workers. A current practice that has caused alarm among workers and govern-

ment officials is for companies to close down their employees' pension plans to gain access to interest earned on the funds.

When the stock market and interest rates began to soar in the early 1980s, many pension funds swelled far beyond their projected sums. Plan sponsors saw the overfunded pension plans as a source of extra income for the company. But the law prevents an employer from gaining access to a pension fund's so-called surplus assets unless the plan is terminated. So to fulfill their legal obligations, companies cancel the plan, buy annuities for the plan's participants, and then pocket the remaining interest sums.

The retirement plans that replace the cancelled plans often are based on individual contributions. In some cases, workers who were vested under the cancelled plans carry none of their vesting status into the replacement plans and have to begin accruing retirement benefits all over again.

Such maneuvers are neither sanctioned nor prohibited by the Internal Revenue Code, and companies have found a legal loophole. They can terminate plans when "erroneous actuarial assumptions" have been made, and the burden is not on them to prove that actuarial assumptions are in error. The practice of terminating healthy plans, known as asset reversion, has become so widespread and attracted so much attention that the Department of Labor has appointed a task force to study the problem. The task force is expected to announce its recommendations this spring.

Job mobility hinders EEs

The problems engineers face in building retirement income are representative of those faced by employees in many industry sectors. Ben Leon, former chairman of the IEEE Pensions Committee, sees engineers' job mobility as their greatest obstacle in accumulating retirement income. Because many engineers work for several employers throughout their careers, they frequently do not work for one company long enough to qualify for the traditional pension plan and begin earning retirement credits.

Because many engineers work for several employers throughout their careers, they frequently do not work for one company long enough to qualify for the traditional pension plan.

The 1974 Employee Retirement Income Security Act (ERISA) made some progress in reducing vesting requirements. Before ERISA was passed, vesting requirements at some companies stretched to 15 or 20 years. ERISA mandates that employees become vested in pension plans after no longer than 10 years with a company.

ERISA was a boon to millions of workers. The Bureau of Labor Statistics reports that in 1972, 32% of workers whose employers offered pension plans were vested in the plans; by 1983, that figure had risen to 48%.

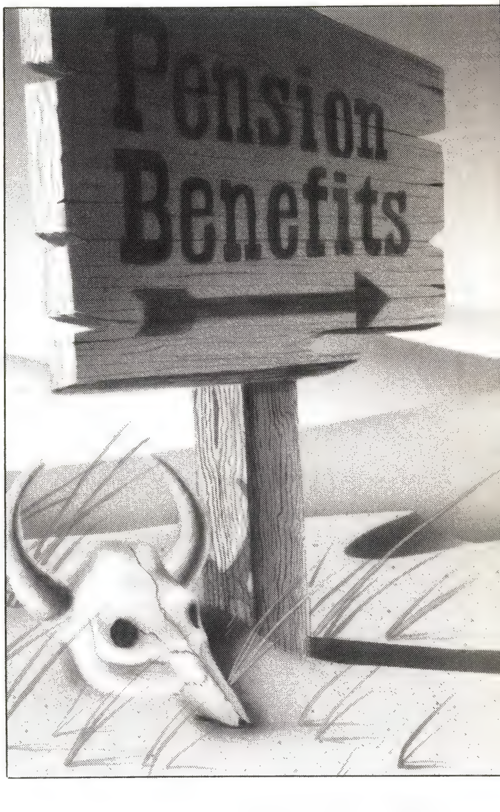
Still, despite ERISA's improvements, Leon argues that 10-year vesting is too long for engineers. He points to an IEEE survey of its members that showed the average length of time an IEEE member works for an employer is seven years. During Leon's tenure as chairman, the IEEE testified in support of 1-year vesting before a Senate committee on aging in June 1985.

In testimony he gave at the same hearing, engineer Ron Sprague related to committee members the consequences of the direction his career has taken. "I have pursued a mobile career in engineering, having an average time per employer of approximately five years. . ." Sprague testified. "In each instance of employment change, I felt that the changes I made were necessary and desirable from a career perspective. Unfortunately, the price my wife and I have paid for this mobility is the forfeiture of opportunities to accrue substantive retirement benefits . . ."

Defined-contribution plans

Shortened vesting periods would qualify more engineers for the traditional pension plans, known as defined-benefit plans, that credit employees for each year they work for the company. But a better plan for engineers, says Leon, is the defined-contribution plan.

Under the terms of a defined-contribution plan, an employee contributes a certain amount of money to the fund. But the plans' rules vary: Some companies match a percentage of the employees' contributions, some allow employees to choose among several investment options, and some permit employees to take all of the funds that accrued to their account when they leave,



while others require that the funds remain in the company's account until the employee reaches retirement age.

"The best thing for engineers and professionals would be a system whereby all pensions would be fully vested, defined-contribution plans," Leon says. Vesting periods for defined-contribution plans are shorter than for typical pension plans—generally two to six years, he says. In some cases, individuals have the option of choosing to invest the money in stocks, low-risk mutual funds, or some combination of the two.

Risks and uncertainties

But there are disadvantages to defined-contribution plans. The funds are not insured, as defined-benefit plan funds are, by the Pension Benefit Guaranty Corp. In addition, the defined-contribution plans incur added uncertainty for employees because there is no formula with which to calculate the final sum. Upon retirement, there is no fixed monthly benefit, only a lump sum from which to draw on.

Another disadvantage to defined-contribution pension plans is that, at some companies, they are no more than the savings plans allowed by section 401(k) of the Internal Revenue Code. The 401(k) plans, as they're known, allow employees to contribute a percentage of their pretax income to an account in their name. No taxes are paid on the money in the account until it is withdrawn. Although 401(k) plans provide an incentive for saving money, they can't be considered true retirement plans because individuals are allowed to borrow from the account after a specified amount of time.

It is a misnomer for companies to institute 401(k) savings plans and refer to them as retirement plans, says Moss. The trend toward such "do-it-yourself" pension plans, she says, is one of the major problems facing pension participants. "The 401(k)s are not pension plans; they're tax shelters and savings plans," says Moss. Jack Andresen, current chairman of the IEEE Pensions Committee, calls the use of 401(k) plans as retirement plans "a perversion of the government's purpose" in permitting the tax-free accounts. "If it's going to be a true retirement plan, you can't allow people to withdraw money, thereby making it simply a savings plan."

Pension-reform legislation

Congress has two pension-reform bills before it, one of which addresses the problem of 401(k) plans that masquerade as retirement plans. A bill sponsored by Senator John Heinz (R-PA) and Congressman William Clay (D-MO) would eliminate the option of withdrawing money from a 401(k) account that is intended to be a retirement plan. The bill would also shorten the vesting period from the current 10-year limit to five years.

The Heinz-Clay bill also targets the problem of pension integration. Integration is the practice of calculating an employee's estimated Social Security benefits and then deducting that amount from the private pension benefit. In some instances, individuals have had their entire pensions eliminated by integration. The Heinz-Clay bill would limit Social Security integration to

Thomas Szumowski

50% of an employee's pension.

The second piece of pension-reform legislation, sponsored by Congresswoman Barbara Kennelly (D-CT), also calls for 5-year vesting and limits integration practices. In addition, the bill breaks some ground in allowing employees to take their accrued pension benefits with them when they leave their employers. Kennelly's bill would allow an employee to take pension benefits of at least $7000 and place them in a tax-free Individual Retirement Account. The concept of making pension funds "portable" begins to address the needs of mobile employees and thus has gained support from many professional quarters, including engineering.

Calling the bills "a step in the right direction," Andresen says they still fall short of a solution. He discounts the impact portable pensions will have on the futures of engineers. "Engineers are mobile, it's true. But even if you haven't been mobile, if you've merely changed jobs once in your career, then you get a fraction of what you would have received had you stayed with one company." Inflation is the real culprit, Andresen believes. He would like to see Congress pass legislation that would require pension-plan sponsors to incorporate a mechanism into their calculations that would adjust participants' payments upward to account for the effects of inflation.

"A pension is deferred compensation, not a discretionary benefit conferred by the company," he says. "There is no place for plans that discriminate against" employees who become vested and then leave the company. As current salaries and wages are adjusted for inflation, so too should the past earnings of vested beneficiaries, he reasons.

"Belatedly, many engineers are finding that when it comes to retirement, they may be without benefits unless they've been investing on their own."

Even if Congress passes legislation that requires companies to restructure their pension plans, engineering representatives agree that engineers' best defense against finding themselves with little or no retirement income is their own knowledge of how pension plans work. Yet there are no two ways about it: Understanding how pensions work takes a great deal of effort. The subject of pensions is a boring one to many people. It involves complex mathematical calculations and dry discussion about vesting, benefits, interest rates, and annuities. Consequently, it's not hard to understand why many employees are unaware of how they will fare under the present system.

"Of those [engineers] under age 50, 75% don't understand the pension system," Leon estimates. "There's no question that self-education would ease the problem. It takes some work to understand your pension. It's a very complex issue; corporations, banks, and insurance companies have experts who work full time on pension issues." Leon confesses that he had been a vested participant of his own pension plan for 10 years before he took the time to assess it, and he did so only then because he was required to make some investment choices at the time.

"Belatedly, many engineers are finding that when it comes to retirement, they may be without benefits unless they've been investing on their own," says Bob Neuman, chairman of the Engineers and Scientists Joint Committee on Pensions, which represents engineers and scientists from more than 20 technical societies.

Unkept promises

Andresen says that one of his goals this year is to prevent more engineers from discovering too late that their employers' retirement plans are "promises they cannot keep." He has actively sought to educate as many engineers as possible through articles he has written for the IEEE's monthly newspaper, *The Institute*, and its magazine for engineering students, *Potentials*. In addition, he has given seminars on the basics of pension plans to audiences at the Wescon and Southeastcon industry trade shows.

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Guides to evaluating your pension status

More information on pensions is available in the following publications:

- *How to evaluate your pension plan* (IEEE Catalog Number UH0161-0), IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. $3 for IEEE members, $4 for nonmembers.
- *Pension Facts*, American Council of Life Insurance, Information and Reference Services, 18 K St NW, Washington, DC 20006. (202) 862-4000.
- *A guide to understanding your pension plan,* Pension Rights Ctr, 1701 K St NW, Washington, DC 20006; (202) 296-3778. $3.

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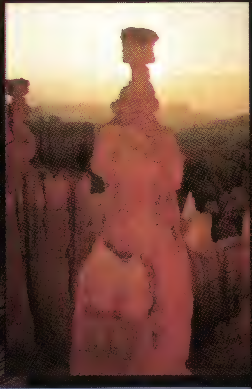

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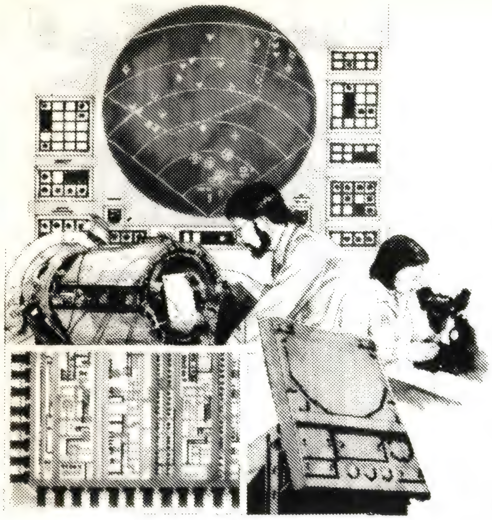

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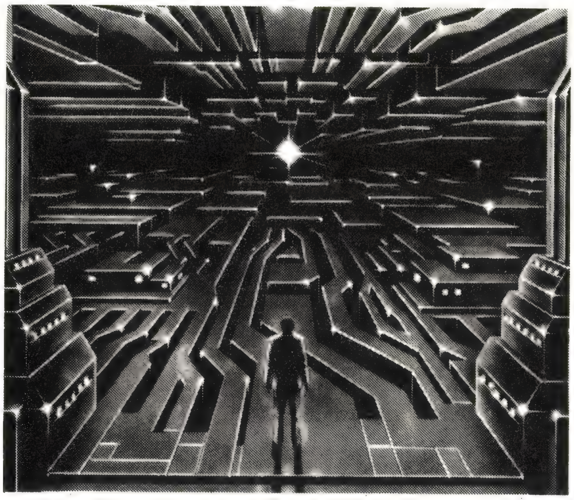

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LOOKING AHEAD

EDITED BY GEORGE STUBBS

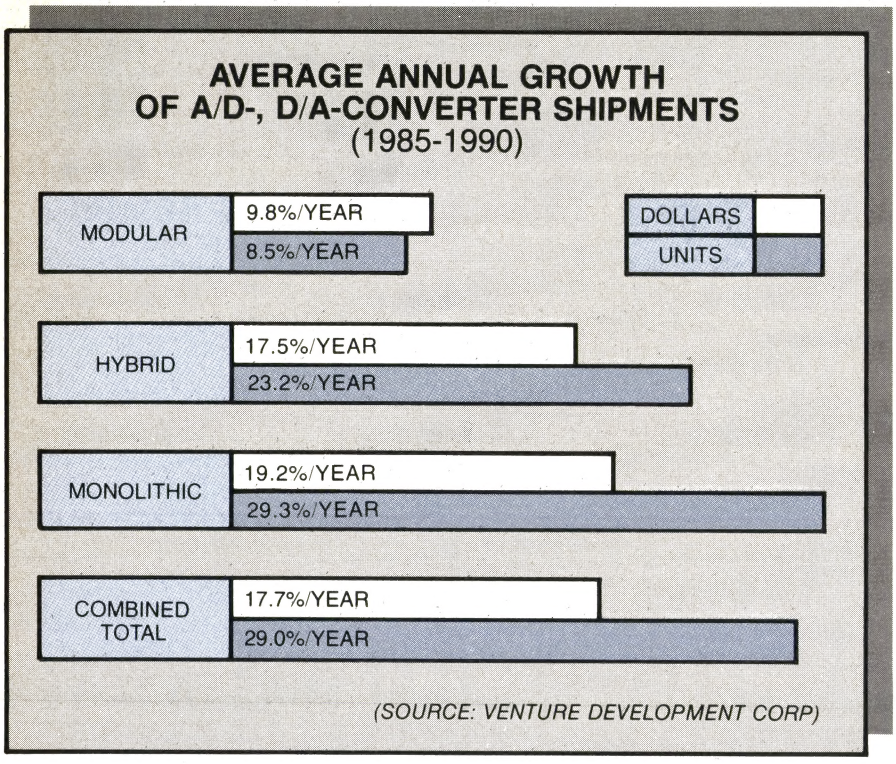
Monolithic units swell data-converter market

The average annual growth of the data-converter market through the remainder of the decade will be 17.7%, reports the market-research company Venture Development Corp (Natick, MA). The dollar value of the total converter market will be $1.13 billion in 1990, more than double 1985's $501.6 million. The force behind this growth, says VDC, will be the increasing popularity of monolithic A/D and D/A converters, whose combined sales will grow at an annual rate of 20%.

Ten years ago, the monolithic data converter was virtually nonexistent, and as recently as four years ago, the highest resolution of these devices was 12 bits. Today, the devices furnish resolutions of 16 bits and higher. Furthermore, compared with hybrid and modular converters, the monolithic parts offer a smaller size with more functions in the same board space, lower costs due to higher production volumes, lower power dissipation and heat generation, and high reliability. Though the demand for hybrid and modular converters will not vanish, these parts will increasingly serve more specialized applications.

Advances in process technology are giving the monolithic devices a big boost. CMOS converters achieve greater chip densities, and, with the aid of VLSI technology, bipolar converters can now handle higher conversion speeds. In addition, BiMOS promises to combine the virtues of bipolar and CMOS technology and have a significant effect upon the market within two or three years.

Power dissipation is important in most data-converter applications, says VDC, and CMOS will consequently be the most popular process technology for A/D and D/A converters through 1990. CMOS parts will be limited only by their slower conversion speed and higher cost. Although high-speed applications may use significant numbers of CMOS flash converters within a few years, CMOS devices will most likely have their greatest impact in such slow- and medium-speed applications as industrial-control systems, medical analyzers, data-acquisition systems, and automatic test equipment.

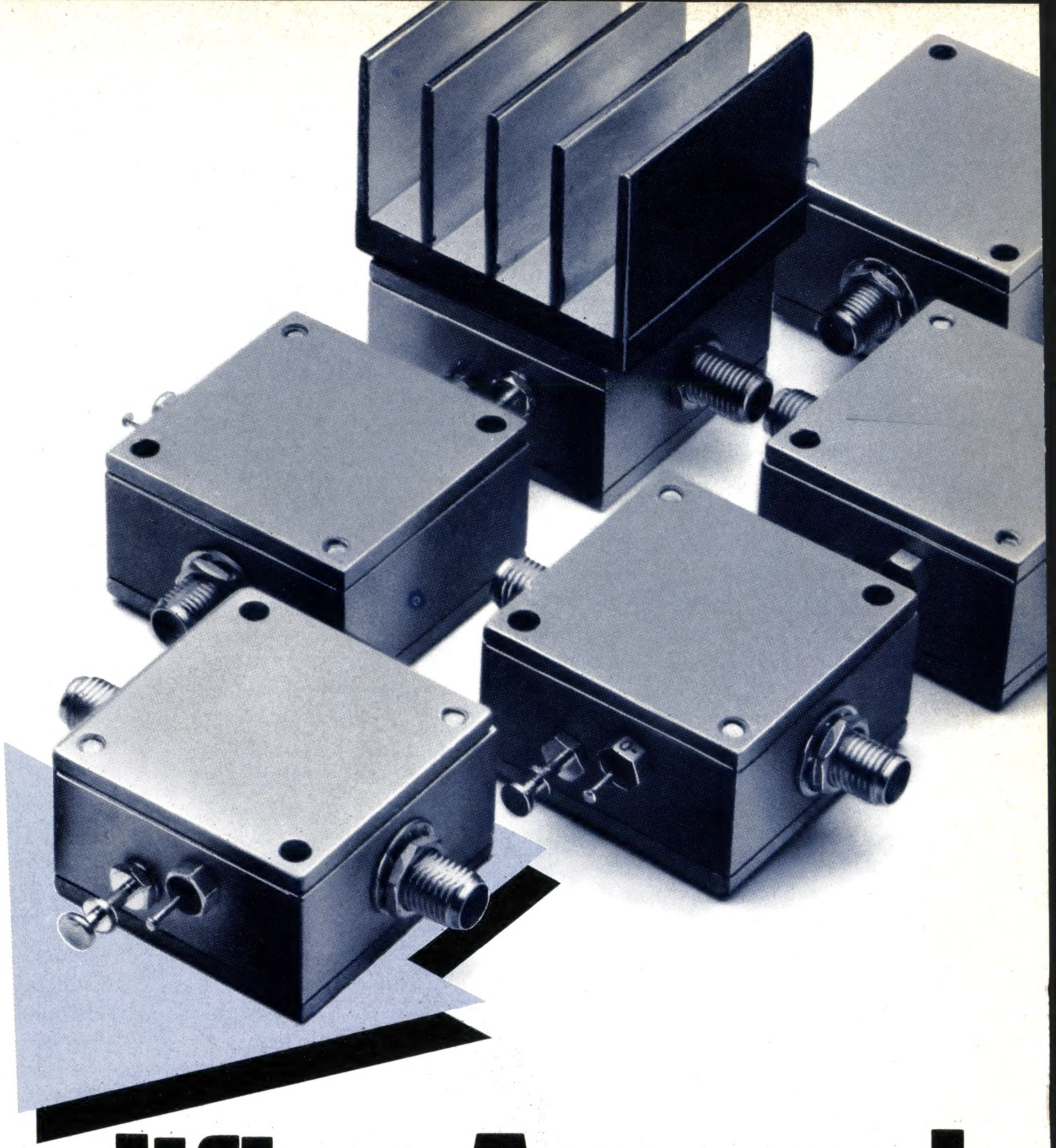


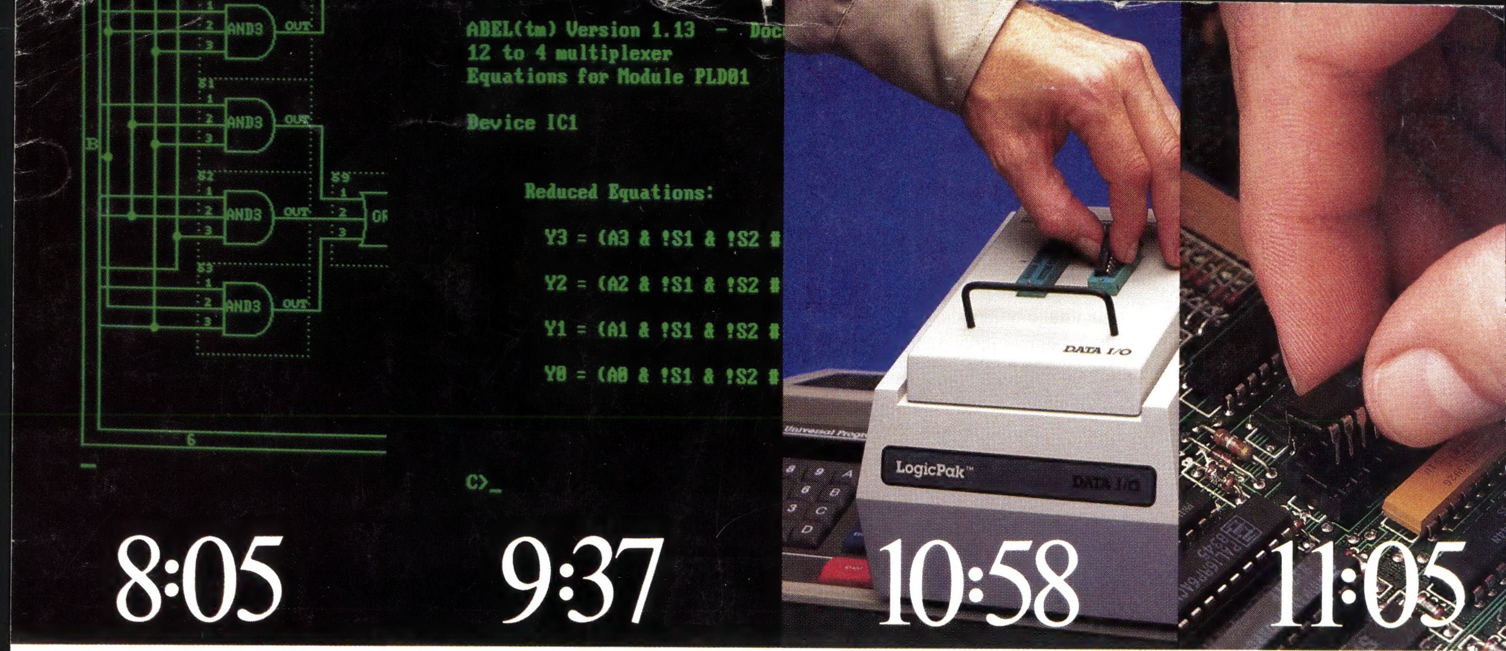
Portable data recorders: programmability the key

For remote data recording, pen and paper have given way to the portable data recorder (PDR), and now the basic PDR is yielding to the programmable PDR. Vendors shipped 145,000 programmable PDRs in 1984 vs 25,000 nonprogrammable units; shipment totals in 1989 will be 453,000 (programmable) vs 65,000 (nonprogrammable), according to the market-research company Frost & Sullivan Inc (New York, NY). The dollar value of these market segments in 1989 will be $465.9 million for programmable PDRs and $43.8 million for the nonprogrammable recorders.

The ubiquitous bar code, so popular in retailing and other industries, has rendered the PDR a necessity in many types of data-collection centers. Further, wireless communications networks have facilitated the transmission of collected data from the PDR to a central site. Programmable PDRs can provide a number of services, including 2-way communication, faster error checking, multiple functions, compatibility with a variety of peripherals and hosts, and the ability to discriminate automatically among a variety of codes.

Frost & Sullivan predicts that competition in the market will be stiff. Approximately 25 manufacturers now vie for market share, and the number is growing. Currently, Telxon and MSI account for 53.7% of the market's dollar value. Norand is ranked third (13.2%) and Motorola fourth (11.7%). Vendors must decide whether they are going to emphasize programmable or nonprogrammable units, and they face some competition from manufacturers of portable computers as well.





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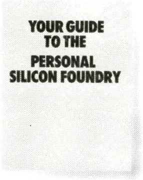

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